Polytec

Hardware Manual

Polytec Scanning Vibrometer

PSV-400

Controller	**OFV-5000**
Junction Box	**PSV-E-401**
Scanning Head	**PSV-I-400**
PC	**PSV-W-401**

Warranty and Service

The warranty for this equipment complies with the regulations in our general terms and conditions in their respective valid version.

This is conditional on the equipment being used as it is intended and as described in this manual.

The warranty does not apply to damage caused by incorrect usage, external mechanical influences or by not keeping to the operating conditions. The warranty also is invalidated in the case of the equipment being tampered with or modified without authorization.

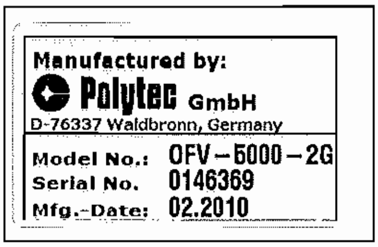
To return the equipment always use the original packaging. Otherwise we reserve the right to check the equipment for transport damage. Please mark the package as fragile and sensitive to frost. Include an explanation of the reason for returning it as well as an exact description of the fault. You can find advice on fault diagnosis in CHAPTER 6.

Trademarks

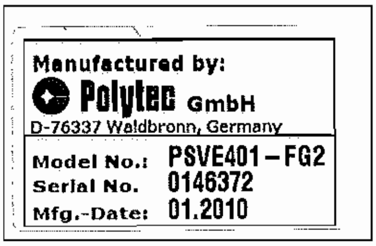
Brand and product names mentioned in this manual could be trademarks or registered trademarks of their respective companies or organizations.

Identification Labels

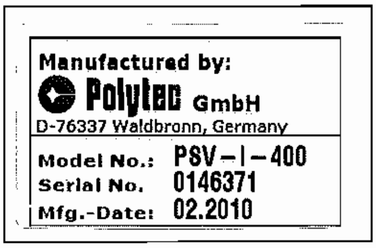
Controller
OFV-5000



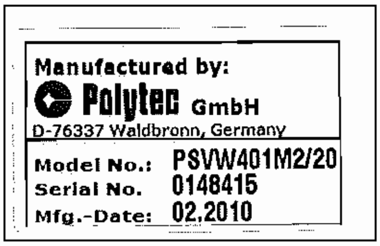
Junction Box
PSV-E-401



Scanning Head
PSV-I-400



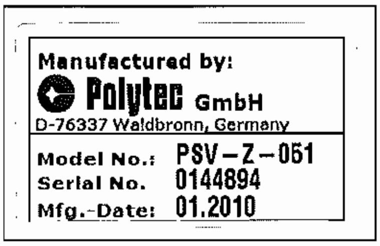
Data Management System
PSV-W-401



Junction Box
PSV-E-408 (optional)

Geometry Scan Unit
PSV-A-420 (optional)

Hand Set
PSV-Z-051



Pan-Tilt Head
PSV-A-T11 (optional)

Test Stand
PSV-A-T18 (optional)

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1 Safety Information

1.1 General Safety Information

Notes

Please read this manual before using the instrument. It will provide you with important information on using the instrument and on safety. This will protect you and prevent damage to the instrument. Pay particular attention to the basic safety information in CHAPTER 1 and the information on installation, operation and maintenance in CHAPTER 3.

Please keep this manual in a safe place and make it available to people using the instrument. Never pass the instrument on without the manual.

In this manual the following graded safety and warning labels are used:

NOTE !

Identifies action required to simplify using the instrument.

CAUTION !

Danger from "Reason for Danger" ! - Identifies the danger caused by an action which could result in damage to the instrument if it is not avoided!

WARNING !

Danger from "Reason for Danger" ! - Identifies a possible danger resulting from an action which could lead to death or (serious) injury if it is not avoided!

Intended use

The instrument is intended for laboratory use and for use in an industrial environment. It may only be used within the limits given in the technical specifications (refer to CHAPTER 7).

Faultless and safe operation of the instrument depends on correct and proper transport and storage, installation and assembly as well as careful operation of the instrument.

When assembling, installing and operating the instrument, the safety and accident-prevention regulations for the respective use must be adhered to.

Qualification

This instrument may only be operated by persons who are familiar with electrical measurement equipment and have been instructed in the use of lasers. Please pay attention to the information on laser safety in SECTION 1.2.

Intervention for maintenance and repair work may only be carried out by the manufacturer himself or by qualified personnel authorized by the manufacturer.

Disposal

An instrument which is no longer required must be disposed of according to local regulations unless otherwise provided for by the manufacturer.

1.2 Information on Laser Safety

1.2.1 Safety Information

The light source of the instrument is a helium neon laser and the light source of the optional scanning head with geometry scan unit PSV-A-420 is a laser diode. It is important to understand that laser light has different properties from ordinary light sources. Laser light is generally extremely intense due to the beam's low divergence. When handling lasers, great care should be taken in any case to make sure that the direct or reflected beam does not enter the eye.

The protective measures taken described in the following support compliance with the safety standards for laser class 2:

NOTE !

Please see CHAPTER 7 for detailed technical specifications!

- Polytec instruments generally comply with the standards **IEC** and **EN 60825-1** and **US 21 CFR 1040.10** and **1040.11** respectively except for deviations pursuant to Laser Notice no. 50, dated 26 July 2001.
- The optical output power of the laser beam emitted from the sensor head is less than 1 mW provided the equipment is used in the manner for which it was intended. This means that the instrument conforms with **laser class 2** and is generally very safe. It is thereby usually assumed that eyes are protected by prevention mechanisms including the blink reflex. This reaction offers appropriate protection under reasonably foreseeable operating conditions. This includes the use of optical instruments for observing the laser beam. Even when optimally focused, the laser beam is not intense enough to harm the skin.
- The scanning head is equipped with a **beam shutter** to block the laser beam during the warm-up, or when the vibrometer is not in use, although switched on.
- An **emission indicator** on the scanning head indicates the activity of the installed laser and thus the potential hazard of laser beams emitted.
- The laser in the scanning heads are switched on using the **key switch** on the appropriate controller. The key can only be removed if the controller and therefore also the laser is switched off.
- The user **should not attempt** to open the housing of the instrument which contains the laser unit as he could be exposed to a higher level of laser energy that is potentially hazardous

WARNING !

Danger from uncontrolled light emission ! - Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

1.2.2 Safety Precautions

Pay attention to the following safety precautions when using the instrument:

- Only qualified and fully trained persons should be entrusted with setting up the instrument, adjusting and operating it!
- Avoid looking directly into the laser beam with the naked eye or with the aid of mirrors or optical instruments!

WARNING !

Danger from laser light ! - It can be dangerous to look directly into the laser beam for any length of time!

NOTE !

Wear suitable laser protection glasses when you have to look at the target area of the laser beam long and hard to set it up!

- Never intentionally direct the laser beam at anyone!

WARNING !

Danger from laser light ! - Do not use any reflective tools, watches etc. when you are working in the beam path of the laser!

- Only open the beam shutter when making measurements!
- Avoid staying in the scanning area! The laser beam can exit the scanning head at an angle of ±20°.
- To position the scanning head, always close the beam shutter. The beam shutter should not be opened until the scanning head has been roughly aligned and mounted securely!
- The laser beam should be terminated at the end of its intended path where this is practically possible.
- Instruments which are not in use should be stored in places which unauthorized persons do not have access to.

1.2.3 Laser Warning Labels

Warning labels The laser warning label for the scanning head are shown in FIGURE 1.1. For the countries in the European Union (EU), label **2** is affixed in the language of the customer's country (see right-hand-side).

1

2

Figure 1.1: Laser warning labels for the scanning head

Position The position of the laser warning labels on the scanning head is shown in FIGURE 1.2.

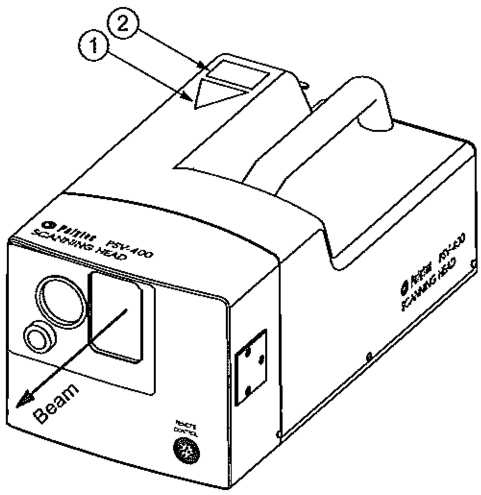

Figure 1.2: Position of the laser warning label on the scanning head

1.3 Information on Electrical Safety

1.3.1 Safety Information

NOTE !

Please note that the information on electrical safety and EMV mentioned here, only applies to controllers permitted by Polytec. You will find the corresponding declaration of conformity in the user manual of the controller.

The instrument complies with the electrical protection class 1 in accordance with the EU directive 2006/95/EEC (low voltage directive). With correct mains connection and intended use, exposure to electric current is prevented by the closed, grounded metal housing.

The instrument is subjected to the EU directive 2004/108/EG (EMC directive) and therefore complies with the limit values for emission and immunity of the standards they are based on (refer also to section SECTION 7.1 and APPENDIX D).

1.3.2 Safety Precautions

Pay attention to the following safety precautions when using the instrument:

- The PSV system components (controller, junction box and PC) are only to be connected up using a three-pin mains cable to AC system 50 / 60 Hz with grounded protective conductor with a nominal voltage of between 100V and 240V.
- Defective mains fuses may only be replaced by fuses of the same kind with the rating given on the back of the instrument.
- If the mains switches are not freely accessible, use the mains plugs to disconnect the devices in case of danger. This means that the mains plug needs to be freely accessible. Otherwise an additional disconnection device must be installed.
- The housing may not be opened when using the instrument as intended. Opening the housing will invalidate the warranty. None of the equipment may be operated with opened housing.

WARNING !

Danger from electrical current! - Intervention for maintenance and repair work may only be carried out by the manufacturer himself or by qualified personnel authorized by the manufacturer.

NOTE !

Before removing parts of the housing for installation and servicing purposes, as a general rule the mains plug should always be unplugged.

- Air inlets and outlets must always be kept free to ensure sufficient cooling. If you notice that the cooling fan is not working, immediately switch the instrument off.

CAUTION !

Danger from heat accumulation ! - If you mount the instrument into a switching cabinet, pay attention that the air inlets in the bottom plate must always be kept free!

2 Introduction

2.1 Area of Application and System Summary

The **P**olytec **S**canning **V**ibrometer **PSV** measures the two-dimensional distribution of vibrational velocities on the basis of laser interferometry. The system components are shown in FIGURE 2.1.

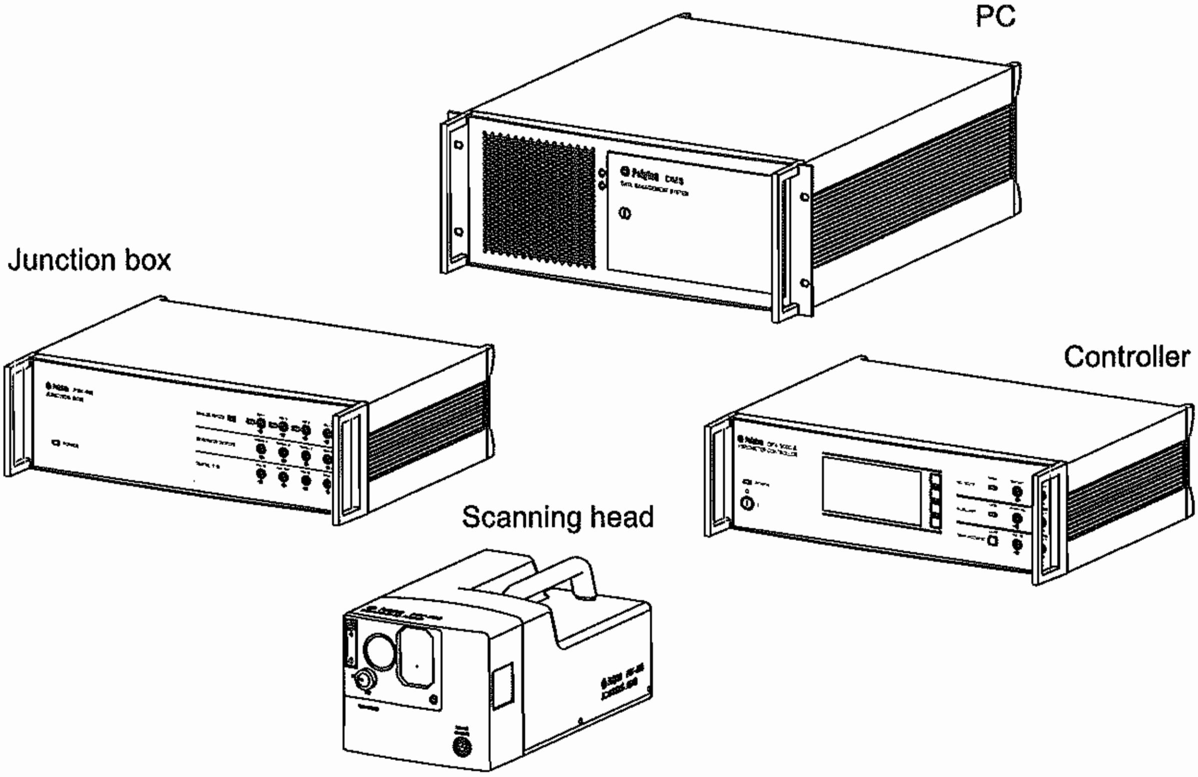

Figure 2.1: System components of the PSV

The interferometer signal is decoded in the **controller** with the velocity decoder. An analog voltage signal is thus generated which is proportional to the vibrational velocity.

The **junction box** is the central connection point between the system components and provides the interfaces for peripheral devices.

The **scanning head** consists of the interferometer, the scanner mirrors to deflect the laser beam and a video camera to visualize the measurement object.

The measurement data is digitally recorded in the **Data Management System**. The PSV software controls the data acquisition and offers user-friendly functions to evaluate the measurement data.

2.2 Polytec's Modular Concept of the Controller

2.2.1 Principle

The construction of Polytec vibrometers is based on a modular principle and thus allows user-specific configuration. The modularity is initially achieved through strict separation of optics and electronics. The controller is designed so that it can be equipped with different signal processing modules optimized for the respective application. The various decoders with digital and analog technology can thereby be combined with all sensor heads. A schematic layout of the corresponding signal flow in the controller is shown in FIGURE 2.2.

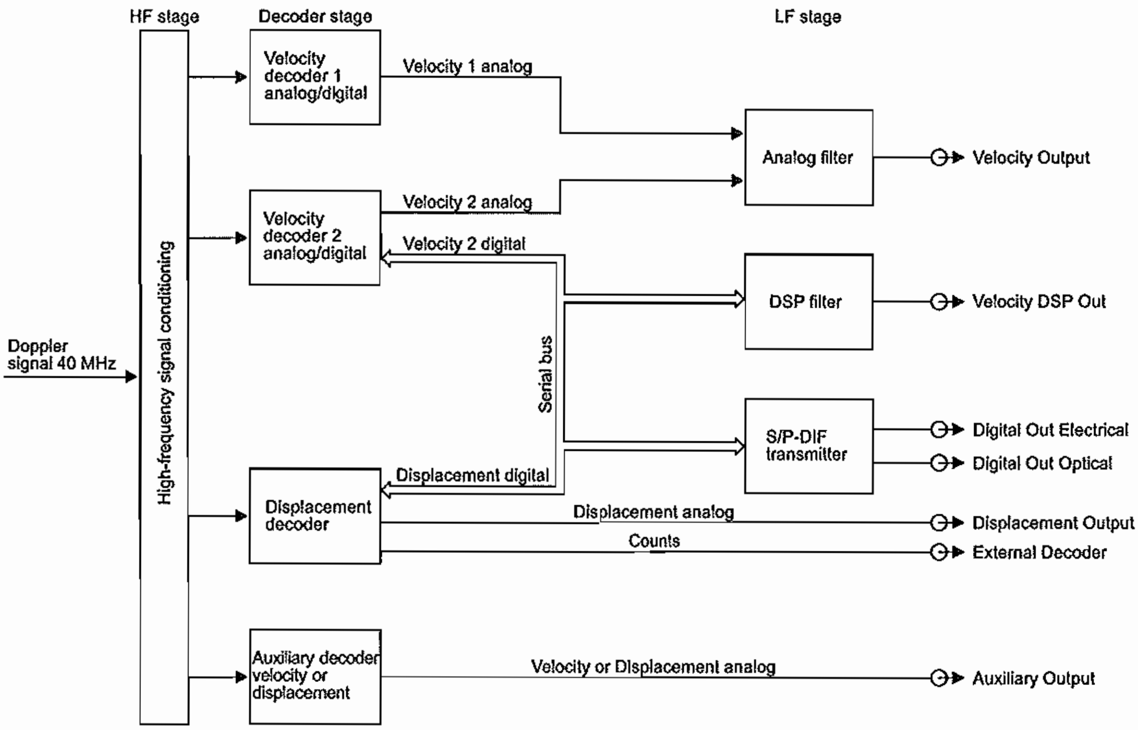

Figure 2.2: Schematic layout of signal flow in the controller

The high-frequency Doppler signal coming from the scanning head initially enters into a high-frequency stage. Whichever decoders the controller has been equipped with, the measurement signal is optimally conditioned here and supplied to the decoder stage. In this stage velocity or displacement information respectively are recovered from the signal. The decoder stage is a followed by a low-frequency stage, consisting of an analog filter module and a digital interface.

2.2.2 Available Decoders

In the following, you will find the decoders listed which are available for the PSV controller. You will find different PSV models with the corresponding decoders in SECTION 2.3.

VD-03

With three measurement ranges, the VD-03 covers the entire dynamic range of the vibrometer in the frequency range 0.5 Hz to 1.5 MHz.

VD-04

With three measurement ranges, the VD-04 covers the entire dynamic range of the vibrometer in the frequency range 0.5 Hz to 250 kHz.

VD-05

The velocity decoder VD-05 with two measurement ranges is suitable to acquire extremely high-frequency vibrations up to 10 MHz. Despite the wide bandwidth and the relatively rough scaling, the VD-05 attains excellent resolution values with spectral signal evaluation. Furthermore the VD-05 is suitable to acquire fast transient motions.

VD-07

The decoder VD-07 equipped with the digital signal processing (DSP technology) has six measurement ranges which allow high-precision, high-resolution acquisition of vibrations in the frequency range from 0 Hz to 350 kHz with a maximum velocity of 0.5 m/s. Apart from the usual analog voltage output, it provides the option of transmitting measurements signals up to 42 kHz signal frequency via the digital interface (S/P-DIF format) directly to suitable equipped signal acquisition systems.

VD-08

Only the PSV -400-H4 instead of the VD-07: The decoder VD-08 equipped with the digital signal processing (DSP technology) has eight measurement ranges which allow high-precision, high-resolution acquisition of vibrations in the frequency range from 0 Hz to 25 kHz with a maximum velocity of 0.5 m/s. Apart from the usual analog voltage output, it provides the option of transmitting measurements signals via the digital interface (S/P-DIF format) directly to suitable equipped signal acquisition systems.

DD-300

The displacement decoder DD-300 has been developed especially for acquiring high-frequency vibrations and impulses in the frequency range from 30 kHz to 24 MHz. The amplitude range limited to ±75 nm is adapted to the physical limitations of high-frequency processes.

VD-09

Only PSV-400-M2, PSV-400-M4 and PSV-400-M2-20: The VD-09 is a digital broadband decoder and is universally suitable for applications in the frequency range up to 2.5 MHz. It is equipped with digital signal processing and has eight measurement ranges which allow extremely accurate and high-resolution acquisition of vibrations or transient movements with a maximum velocity of 10 m/s. The lower cutoff frequency of 0 Hz (DC capability) enables the decoder VD-09 to be used unlimited also for the acquisition of uniform, intermittent or rotational movements.

2.3 The Different PSV Models

The decoder and filter in the controller as well as the data acquisition board in the PC determine the characteristics of the PSV. Depending on the application there are different models available; their characteristics are summarized in TABLE 2.1.

Table 2.1: Summary of the PSV models

PSV model	**PSV-400-H4** **High frequency model** **4 channels**	**PSV-400-B** **Basic model**
Controller	OFV-5000	OFV-5000
Velocity Decoders	VD-03 + VD-08	VD-04
Measurement range [$\frac{mm}{s}$/V]	VD-03: 10/100/1000 VD-08: 8 ranges from 0.2 to 50	10/100/1000
Maximum frequency	VD-03: 0.25/1.5/1.5 MHz VD-08: 5 kHz to 25 kHz	250 kHz
Digital signal processing	PSV-W-401-H4	PSV-W-401-B
Data acquisition board	PCI-4462 (+ PCI-4462)[1]	PCI4461
Internal function generator	PCI-6711	
Maximum bandwidth	80 kHz	40 kHz
Input channel (simultaneous)	4 (8)	2
Output channel (generator)	4	(1)
Maximum bandwidth (generator)	80 kHz	(20 kHz)

[1] The designations in brackets are available as an option.

PSV model	**PSV-400-M2** **High frequency model** **2 channels**	**PSV-400-M4** **High frequency model** **4 channels**
Controller	OFV-5000	OFV-5000
Velocity Decoders	VD-09 + VD-07	VD-09 + VD-07
Measurement ranges [$\frac{mm}{s}$/V] -digital-	VD-09: 8 ranges from 5 to 1000 VD-07: 6 ranges from 1 to 50	VD-09: 8 ranges from 5 to 1000 VD-07: 8 ranges from 1 to 50
Maximum frequency	VD-09: 0.1 MHz to 2.5 MHz VD-07: 20 kHz to 350 kHz	VD-09: 0.1 MHz to 2.5 MHz VD-07: 20 kHz to 350 kHz
Digital signal processing	PSV-W-401-M2	PSV-W-401-M4
Data acquisition board	PCI-6111	PCI-6110
Internal function generator		
Maximum bandwidth	1 MHz (2 MHz)[1]	1 MHz (2 MHz)
Input channel (simultaneous)	2	4
Output channel (generator)	1	1
Maximum bandwidth (generator)	500 kHz	500 kHz

[1] The designations in brackets are available as an option.

PSV model	PSV-400-M2-20 High frequency model 2 channels (max. 20 MHz)
Controller	OFV-5000
Velocity Decoders	VD-09 + VD-07 + VD-05
Measurement ranges [$\frac{mm}{s}$/V]	VD-09: 8 ranges from 5 to 1000 VD-07: 6 ranges from 1 to 50 VD-05: 100/500
Maximum frequency	VD-09: 0.1 MHz to 2.5 MHz VD-07: 20 kHz to 350 kHz VD-05: 10 MHz
Displacement decoder	(DD-300)[1]
Measurement range [nm/V]	50 (DD-300)[2]
Maximum measurable displacement	±75 nm (DD-300)
Maximum frequency	24 MHz (DD-300)
Digital signal processing	PSV-W-401-M2-20
Data acquisition board	MI.3025
Internal function generator	MI.6030
Maximum bandwidth	40 MHz
Input channel (simultaneous)	2
Output channel (generator)	1
Maximum bandwidth (generator)	40 MHz

[1] Instead of the velocity decoder VD-05

[2] At load resistance 50 Ω

3 First Steps

3.1 Unpacking and Inspection

Unpacking

The PSV is made up of the following components:

- Controller OFV-5000
- Scanning head PSV-I-400

> **CAUTION !**
>
> **Danger from hard jolting !** - Protect the unpacked scanning head from hard jolts as these can lead to misalignment of the interferometer!

- Junction box PSV-E-401
- Data management system PSV-W-401 consisting of industrial PC with keyboard and mouse (according to the model)
- TFT monitor with monitor cable and mains cable
- Tripod with fluid stage VIB-A-T02
- Hand set PSV-Z-051 (optional for PSV-400-B)
- Umbilical cable
- Interferometer cable
- S-Video cable with adapter cable
- Acquisition cable
- 3 BNC cable
- RS-232(X) cable (cross-wired)
- USB cable
- Generator cable (only PSV-400-H4 and -B)
- Data acquisition and generator cable (ACQ/GEN 20MHz, only PSV-400-M2-20)
- SMB-SMB connecting cable (only PSV-400-M2-20)
- 3 mains cables

Optional

- Junction box PSV-E-408 with plug-in power supply (only PSV-400-H4)
- Acquisition cable (only PSV-400-H4)
- System cabinet PSV-A-010
- Close-up unit PSV-A-410
- Scanning head with geometry scan unit PSV-A-420
- Acoustic gate unit PSV-A-430 with BNC cable
- Heavy duty tripod with motorized pan-tilt stage, connector box and mains cable PSV-A-T11 (instead of the VIB-A-T02)
- Test stand PSV-A-T18
- Hand set PSV-A-PDA (only PSV-400-H4)

Inspection

Please pay attention to the following steps when unpacking PSV:

1. Check the packaging for signs of unsuitable handling during transport.
2. After unpacking, check all components for external damage (scratches, loose screws, damaged lenses etc.).
3. In the case of a wrong delivery, damage or missing parts, please inform your local Polytec representative immediately and give them the serial number of the instruments. The identification labels can be found on the back of the instruments, on the bottom side of the scanning head as well as on the inside cover of this manual.
4. Carefully retain the original packaging in case you have to return the instrument PSV.

Install the PSV as described in SECTION 3.4 and carry out a functional test as described in SECTION 3.5.

3.2 Operating and Maintenance Requirements

Ambient conditions

The PSV can be operated in dry rooms under normal climatic conditions (refer to CHAPTER 7). In particular the optical components in the scanning head are sensitive towards moisture, high temperatures, shocks and dirt.

If the PSV is taken into operation after being stored in a cold environment, a sufficient acclimatization period should be allowed before switching it on. Avoid condensation on the optical components caused by a rapid change in temperature.

Assembly

The scanning head should not be set up provisionally but should be securely mounted as free of vibration as possible on a stable tripod or an alternative stable base using the mounting threads.

Cooling

It is very important to ensure that there is sufficient air circulation to cool the system components. The back panel of the instruments must be at least 50 mm away from the wall.

CAUTION !

⚠ **Danger from heat accumulation !** - The PSV may only be operated in the system cabinet if the cover of the system cabinets are removed. Otherwise generation of heat can cause damages in the instruments!

CAUTION !

⚠ **Danger from heat accumulation !** - If you mount the instrument into a switching cabinet, pay attention that the air inlets in the bottom plate must always be kept free!

Connecting cables

As a general rule, the PSV may not be switched on until all connecting cables have been connected up. Make sure that all jacks are connected properly and firmly. Plug in the SCSI-type connectors of the acquisition cable with great care at the right angles. Only use the original RS-232(X) cable from Polytec for the RS-232 connection (cross-wired).

Protect all connecting cables from mechanical damage and from high temperatures. The bending radius should not fall below 50 mm.

Mains connection

The mains voltage input of the instruments is designed to be a wide range input and can be connected up to all mains voltages with nominal values in the range of 100 V to 240 V.

The plug-in power supply, contained in the scope of supply, for the junction box PSV-E-408 offers a wide range input and can therefore be connected up to all mains voltages with nominal value in the range of 100V to 240V.

Warming-up

The helium neon laser in the scanning head will take a little while to reach the optimal working temperature after it has been switched on. The PSV therefore reaches its optimal properties after a warm-up period of approx. 30 minutes. After that you can be sure that all components are working properly in accordance with the specifications. Less critical measurements, such as to align the PSV for example, can however be carried out before this warm-up period has expired.

Cleaning

The housing surfaces of the instruments can be cleaned with mild detergent or disinfectant solutions. Organic solvents must not be used.

Pan-tilt stage

Avoid any additional weight on the pan-tilt stage by placing the objects on top of the scanning head as this can put strain on the pan-tilt stage.

Installation of other components

Hard or software components which do not belong to the PSV system can damage the system. Using them will invalidate the warranty. If you want to install such components please contact Polytec.

Opening the instruments

It is not necessary to open the housings when using the equipment as intended and will invalidate the warranty.

3.3 Control Elements

3.3.1 Controller

Front panel The front panel of the controller is shown in FIGURE 3.1.

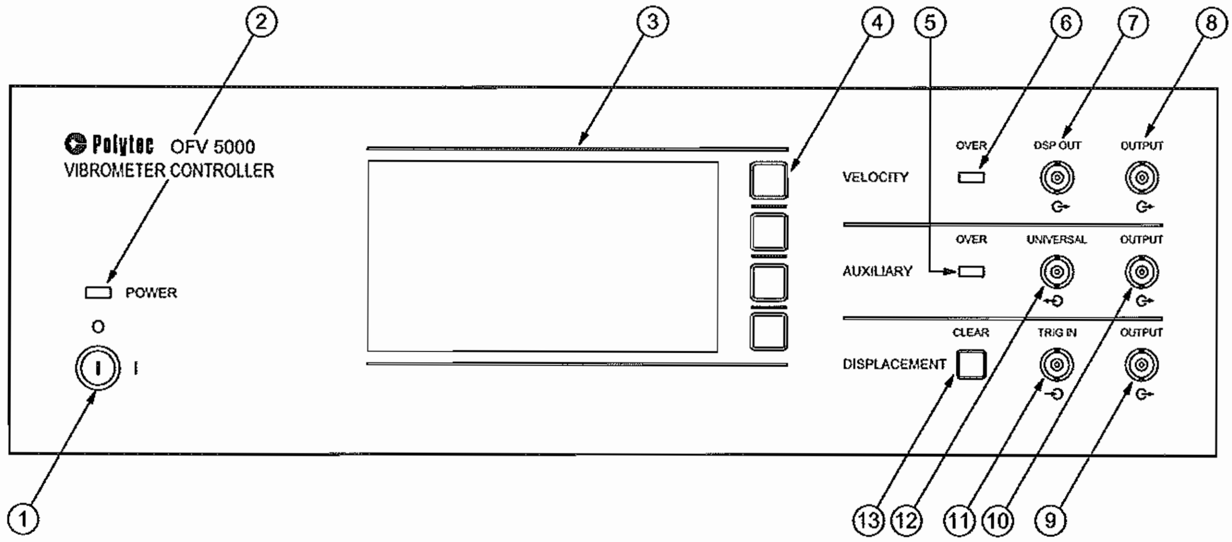

Figure 3.1: Front view of the controller

1 **Mains switch**

The key switch disconnects the controller from the mains (position O) and is used to switch it off in case of danger.

> **CAUTION !**
>
> **Danger from mishandling !** - Always connect up all connecting cables before you switch the controller on! If you do not keep the order, damage to the instrument may occur!

2 **POWER** LED

The LED lights up, if the controller has been switched on with the key switch (position I) and indicates that the controller is ready to operate.

3 **Liquid Crystal Display (LCD)** with background lighting

The display shows the configuration and settings of the controller. In the PSV, the controller is operated via the software (refer to software manual). Operating the controller without the software is described detailed in SECTION 5.15.

4 **Function keys**

Use these keys to navigate through the menus of the controller or change the settings respectively according to the icons shown in the display next to them. In the PSV, the controller is operated via the software (refer to software manual). Operating the controller without the software is described detailed in SECTION 5.15.

5 AUXILIARY **OVER** LED for the auxiliary decoder

The LED lights up if the output voltage either reaches the positive or the negative full scale value of the selected measurement range. If the LED lights up permanently, the next highest measurement range must be selected if available (refer also to SECTION 4.2.1).

6 VELOCITY **OVER** LED for the velocity decoder

The LED lights up if the output voltage either reaches the positive or the negative full scale value of the selected measurement range. If the LED lights up permanently, the next highest velocity measurement range must be selected if available (refer to SECTION 4.2.1).

7 Signal output VELOCITY **DSP OUT** (BNC jack)

Output signal of the optional DSP filter (only when using the adaptive DSP filter)

8 Signal output VELOCITY **OUTPUT** (BNC jack)

Output signal of the velocity decoder. The voltage at this output is proportional to the instantaneous vibrational velocity of the object. The voltage is positive when the object is moving towards the scanning head.

9 Signal output DISPLACEMENT **OUTPUT** (BNC jack)

Output signal of the displacement decoder. This output is only active if a displacement decoder has been installed. The voltage at this output is proportional to the instantaneous deflection of the object. The voltage increases when the object is moving towards the scanning head.

10 Signal output AUXILIARY **OUTPUT** (BNC jack)

Output signal of the auxiliary decoder. This output is only active if an auxiliary decoder has been installed.

11 Signal input DISPLACEMENT **TRIG IN** (BNC jack)

This input is only active if a displacement decoder has been installed. This signal input can be used to reset the displacement decoder remotely to the zero position.

12 Signal output AUXILIARY **UNIVERSAL** (BNC jack)

Signal output for special functions of the auxiliary decoder

13 **CLEAR** key for the displacement decoder

This key is only active if a displacement decoder has been installed. This key can be used to reset the displacement decoder manually to the zero position.

Back panel The back panel of the controller is shown in FIGURE 3.2.

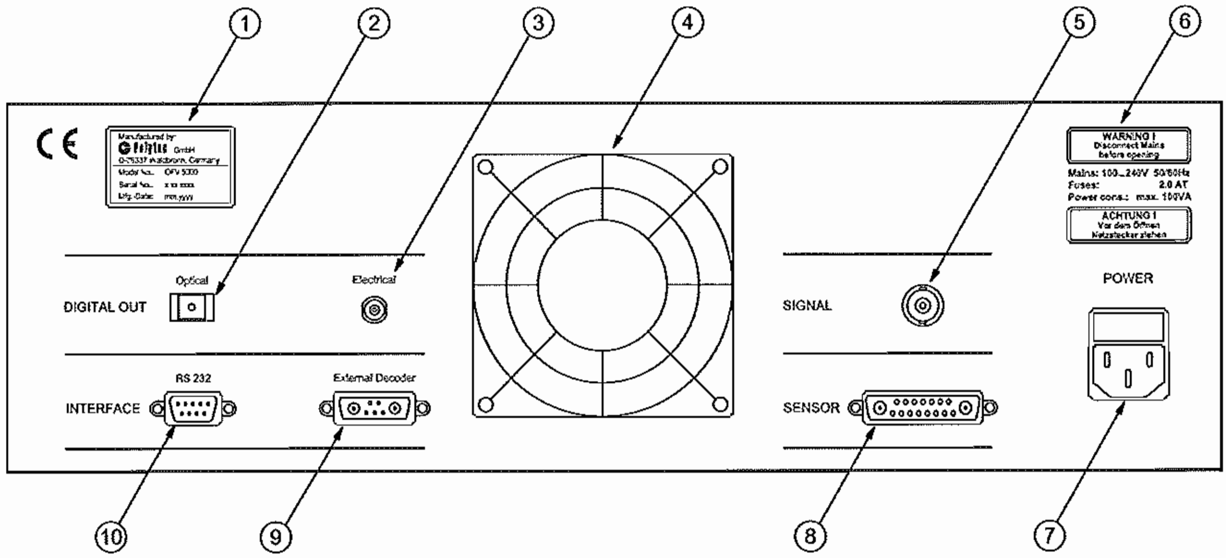

Figure 3.2: Rear view of the controller

1 **Identification label**

On the identification label you will find, among other things, the serial number of the instrument.

2 Digital signal output **Optical** (TOSLINK jack)

Connector for an optical fiber cable with a TOSLINK plug to transmit the S/P-DIF signal

3 Digital signal output **Electrical** (TRIAX jack)

Connector for the optional S/P-DIF cable to transmit the S/P-DIF signal

4 **Cooling fan**

CAUTION !

Danger from heat accumulation ! - This opening must always be kept free to ensure sufficient cooling. The distance to the wall must be at least 50 mm! Furthermore, provide sufficient free space under the controller as air vents are located there!

5 Signal output **SIGNAL** (BNC jack)

The DC voltage at this output is proportional to the logarithm of the optical signal level. This signal can be used to monitor the optical measurement conditions externally.

6 **Instrument warning label**

Label with technical data for the fuses and the mains connection

7 **Mains connection** (socket for standard power cord with built-in fuses)

The mains voltage input is designed to be a wide range input (refer also to SECTION 3.2).

WARNING !

Danger from electrical current ! - Working on an open housing can lead to personal injury!

NOTE !

Before checking the fuses, the mains plug must be disconnected!

8 **SENSOR** connector (Sub-D jack)
Connector for the interferometer cable from the junction box

9 External Decoder **interface** (Sub-D jack)
Not used for PSV systems!

10 **RS 232** interface (9-pin Sub-D connector)
Connector for the RS-232(X) cable from the junction box to control the PSV via the software

NOTE !

To control the PSV via the software, in the controller the transfer rate **must** be set to **115200 Baud** (refer also to SECTION 5.16)!

3.3.2 Junction Box PSV-E-401

Front panel The front panel of the junction box is shown in FIGURE 3.3.

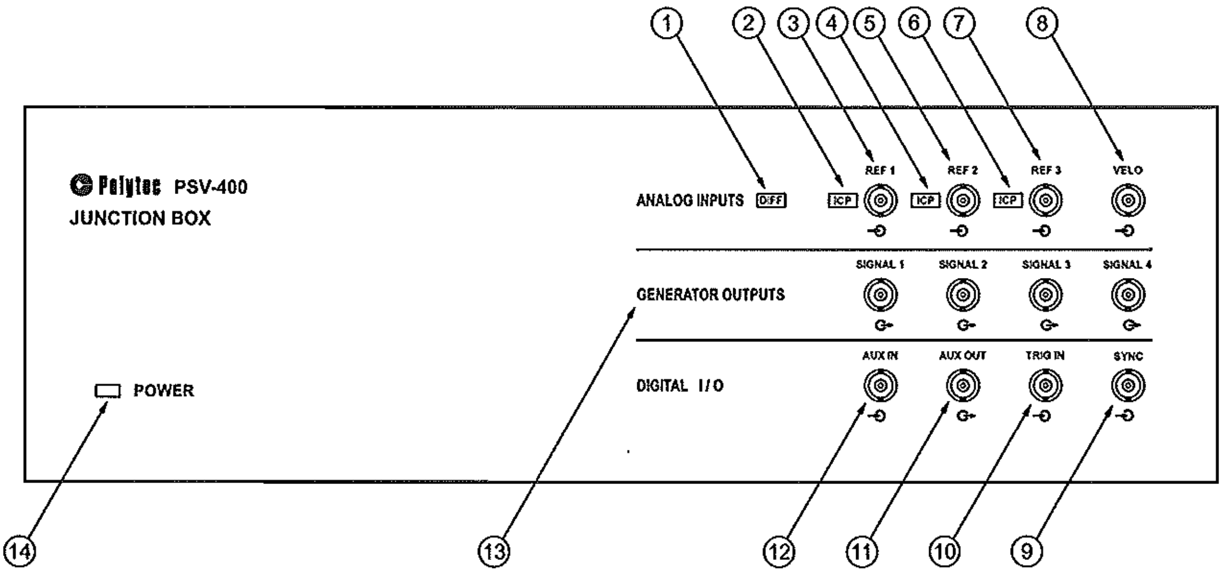

Figure 3.3: Front view of the junction box PSV-E-401

1 **DIFF** LED for the differential input

The LED being lit indicates that for the channels (VELO, REF 1, REF 2, REF 3) selected in the software the Differential Input is activated in the software (differential mode = not grounded). You can thus avoid ground loops and generally improve transmission reliability. Activating and deactivating the differential input is described in the software manual.

2 **ICP** LED for **REF 1**

The LED being lit indicates that for the reference input REF 1 the IEPE power supply (ICP®) is activated in the software.

3 Analog input **REF 1** (BNC jack)

Analog voltage input for the reference signal. To this jack you can also connect sensors that are equipped with an integrated amplifier according to the IEPE concept (ICP®) (4 mA/24 V). Activating or deactivating the IEPE power supply (ICP®) is described in your software manual.

4 **ICP** LED for **REF 2**, only PSV-400-H4 and PSV-400-M4

The LED being lit indicates that for the reference input REF 2 the IEPE power supply (ICP®) is activated in the software.

5 Analog input **REF 2** (BNC jack), only PSV-400-H4 and PSV-400-M4

Analog voltage input for the second, additional reference signal. To this jack you can also connect sensors that are equipped with an integrated amplifier according to the IEPE concept (ICP®) (4 mA/24 V). Activating or deactivating the IEPE power supply (ICP®) is described in your software manual.

6 **ICP** LED for **REF 3**, only PSV-400-H4 and PSV-400-M4

The LED being lit indicates that for the reference input REF 3 the IEPE power supply (ICP®) is activated in the software.

7 Analog input **REF 3** (BNC jack), only PSV-400-H4 and PSV-400-M4

Analog voltage input for the third, additional reference signal. To this jack you can also connect sensors that are equipped with an integrated amplifier according to the IEPE concept (ICP®) (4 mA/24 V). Activating or deactivating the IEPE power supply (ICP®) is described in your software manual.

8 Analog input **VELO** for the velocity signal (BNC jack)

Analog voltage input for the velocity signal from the controller

9 TTL output **SYNC** (BNC jack)

Synchronization pulse for the signal of the internal function generator PSV-400-B: The output is only active with the corresponding option.

10 TTL input **TRIG IN** (BNC jack)

TTL input for an external trigger signal

11 TTL output **AUX OUT** (BNC jack)

TTL output for especially application, programmable via Visual Basic® Engine

12 TTL input **AUX IN** (BNC jack)

TTL input for especially application, programmable via Visual Basic® Engine

13 Generator output **SIGNAL 1** (BNC jack)

Analog voltage output for the signal of the internal function generator PSV-400-B: The output is only active with the corresponding option.

Generator outputs **SIGNAL 2** to **SIGNAL 4** (BNC jacks),
only PSV-400-H4: Here are three additional analog voltage outputs available for the signals of the internal function generator

14 **POWER** LED

The LED lights up when the junction box is connected up correctly to the controller and the key switch on the controller is turned to position I. The LED indicates that the junction box is ready to operate.

Back panel The back panel of the junction box is shown in FIGURE 3.4.

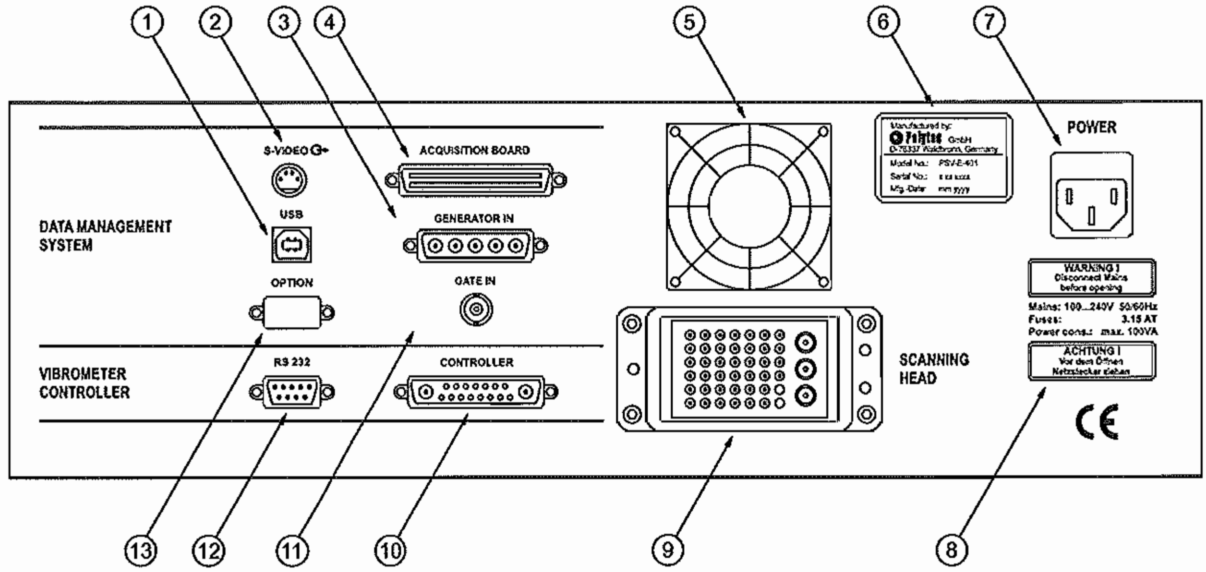

Figure 3.4: Rear view of the junction box PSV-E-401

1 **USB** interface (Universal Serial Bus, type B)

Connector for the USB cable from the PC to control the PSV via the software

2 **S-VIDEO** output (4-pin circular jack)

Connector for the S-Video cable to the PC to transmit the video signal

3 Connector **GENERATOR IN** (Sub-D plug)

PSV-400-H4, -B: Connector for the generator cable from the PC to transmit the signals of the internal function generator

PSV-400-M2-20: Connector for the acquisition and generator cable ACQ/ GEN 20 MHz from the PC to transmit the measurement and control signals as well as the signals of the internal function generator

4 Connector **ACQUISITION BOARD** (SCSI-II type)

Connector for the Acquisition cable to the PC to transmit both measurement and trigger signals; with the PSV-400-M2-20, the connector is not connected!

5 **Cooling fan**

CAUTION !

Danger from heat accumulation! - This opening must always be kept free to ensure sufficient cooling. The distance to the wall must be at least 50mm! Furthermore, provide sufficient free space under the junction box as air vents are located there!

6 **Identification label**

On the identification label you will find, among other things, the serial number of the instrument.

7 **Mains connection** (socket for standard power cord with built-in fuses)

The mains voltage input is designed to be a wide range input (refer also to SECTION 3.2.

WARNING !
Danger from electrical current! - Working on an open housing can lead to personal injury!

NOTE !
Before checking the fuses, the mains plug must be disconnected!

CAUTION !
Danger from mishandling ! - Always check the fuses before installing the PSV!

8 **Instrument warning label**

Label with technical data for the fuses and the mains connection

9 Connector **SCANNING HEAD**(industrial-style)

Connector for the Umbilical cable from the scanning head

10 Connector for the **CONTROLLER** (Sub-D jack)

Connector for the interferometer cable to the controller OFV -5000

11 TTL input **GATE IN** (BNC jack)

TTL input for the external Gate signal to start and stop a measurement. Level LOW of the signal discontinues the measurement
PSV -400-B: The input is only active with the corresponding option.

12 **RS 232** interface (9-pin Sub-D plug)

Connector for the RS-232(X) cable to the controller to control the PSV via the software.

13 Connector **OPTION**

For special function, in the standard version not installed!

3.3.3 Junction Box PSV-E-408 (optional, only PSV-400-H4)

Front panel The front panel of the junction box is shown in FIGURE 3.5.

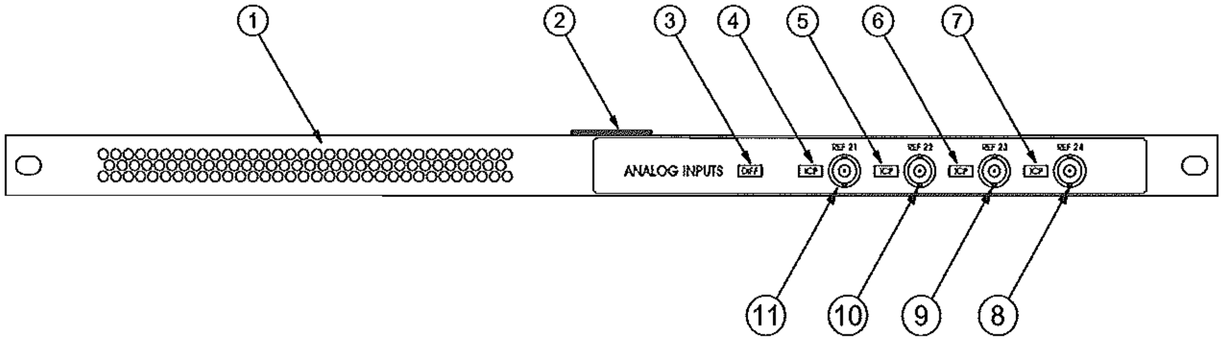

Figure 3.5: Front view of the junction box PSV-E-408

1 **Air vents**

> **CAUTION !**
>
> **Danger from heat accumulation !** - To ensure sufficient cooling, these openings must kept free!

2 **Identification label**

On the identification label you will find, among other things, the serial number of the instrument.

3 **DIFF** LED for the differential input

The LED being lit indicates that for the channels (REF 21, REF 22, REF 23, REF 24) selected in the software the Differential Input is activated in the software (differential mode = not grounded). You can thus avoid ground loops and in certain cases improve transmission reliability. Activating and deactivating the differential input is described in the software manual.

4 **ICP** LED for **REF 21**

The LED being lit indicates that for the reference input REF 21 the IEPE power supply (ICP®) is activated in the software.

5 **ICP** LED for **REF 22**

The LED being lit indicates that for the reference input REF 22 die IEPE power supply (ICP®) is activated in the software.

6 **ICP** LED for **REF 23**

The LED being lit indicates that for the reference input REF 23 the IEPE power supply (ICP®) is activated in the software.

7 **ICP** LED for **REF 24**

The LED being lit indicates that for the reference input REF 24 the IEPE power supply (ICP®) is activated in the software.

8 Analog input **REF 24** (BNC jack)

Analog voltage input for the reference signal. To this jack you can also connect sensors that are equipped with an integrated amplifier according to the IEPE concept (ICP®) (4 mA/24 V). Activating or deactivating the IEPE power supply (ICP®) is described in your software manual.

9 Analog input **REF 23** (BNC jack)

Analog voltage input for the reference signal. To this jack you can also connect sensors that are equipped with an integrated amplifier according to the IEPE concept (ICP®) (4 mA/24 V). Activating or deactivating the IEPE power supply (ICP®) is described in your software manual.

10 Analog input **REF 22** (BNC jack)

Analog voltage input for the reference signal. To this jack you can also connect sensors that are equipped with an integrated amplifier according to the IEPE concept (ICP®) (4 mA/24 V). Activating or deactivating the IEPE power supply (ICP®) is described in your software manual.

11 Analog input **REF 21** (BNC jack)

Analog voltage input for the reference signal. To this jack you can also connect sensors that are equipped with an integrated amplifier according to the IEPE concept (ICP®) (4 mA/24 V). Activating or deactivating the IEPE power supply (ICP®) is described in your software manual.

Back panel

The back panel of the junction box is shown in FIGURE 3.6.

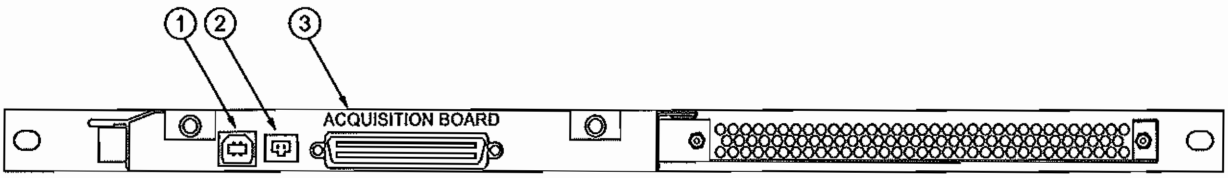

Figure 3.6: Rear view of the junction box PSV-E-408

1 **USB** interface (Universal Serial Bus, type A)

Connector for the USB cable to the PC

2 Connector for the **power supply cable** (5 VDC)

Connector for the plug-in power supply of the junction box (refer also to SECTION 3.2)

3 Connector **ACQUISITION BOARD** for the data acquisition board (SCSI-II type)

Connector for the Acquisition cable to the PC to transmit the additional reference signals

3.3.4 PC

Front panel for all models

The front panel of the PC for all PSV models is shown in FIGURE 3.7. The lockable front flap is shown as transparent.

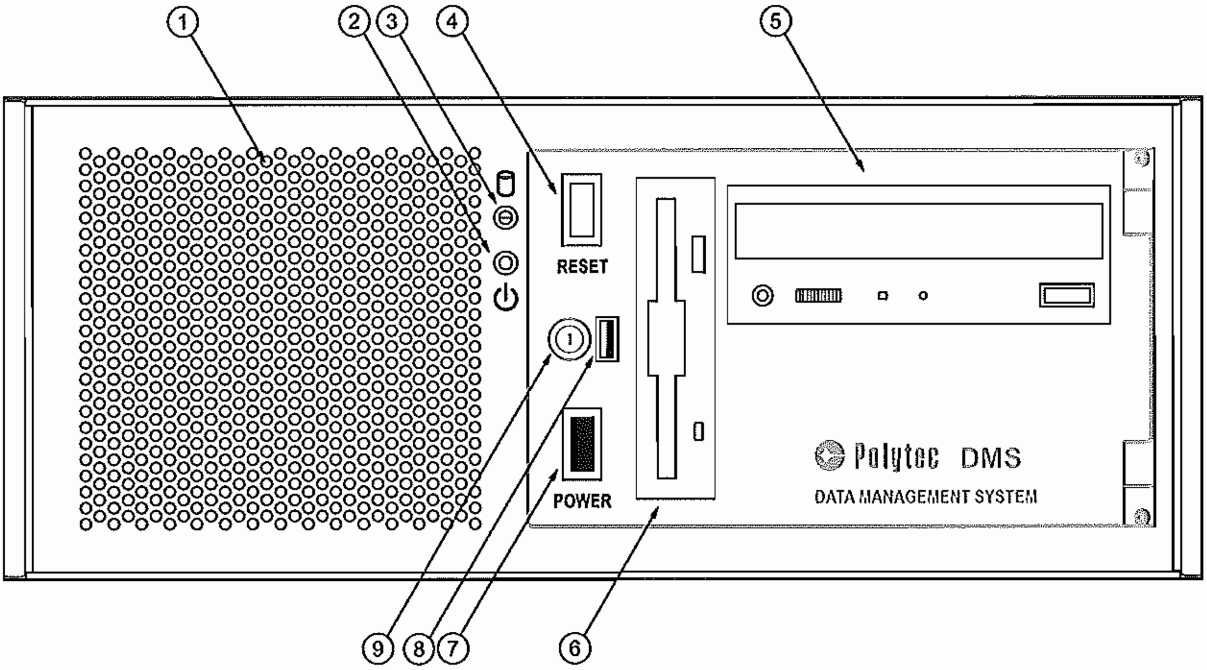

Figure 3.7: Front view of the PC

1 Cooling fan

CAUTION !
Danger from heat accumulation ! - To ensure sufficient cooling, these openings must kept free!

2 POWER LED

The green LED lights up when the PC is switched on using the mains switch on the back and the black key on the front has been pressed.

3 HDD LED

The yellow LED being lit indicates the activity of the hard disk drive (HDD) in the PC.

4 RESET key

This white key is used to reset all components of the PC and the PC is restarted. The status of the PC is the same as it was after first being switched on.

5 DVD recorder

You will find an exact description of the DVD recorder in the user manual of the manufacturer.

6 **3,5" disk drive**

7 **POWER** key

By pressing the black key, the PC will be switched on.

8 **USB** interface (Universal Serial Bus, type A)

Connector for a mass storage device

9 **Lock with key** in the front flap

To secure the PC for unauthorized using, the front flap can be locked using the key.

Back panel for models -H4 and -B

The back panel of the PC for the PSV model -H4 is shown in FIGURE 3.8. The order of the plug-in boards may vary from that shown in the picture. The PC of the PSV model -B contains another data acquisition board. You will find a description of the connectors of the data acquisition board in the following section.

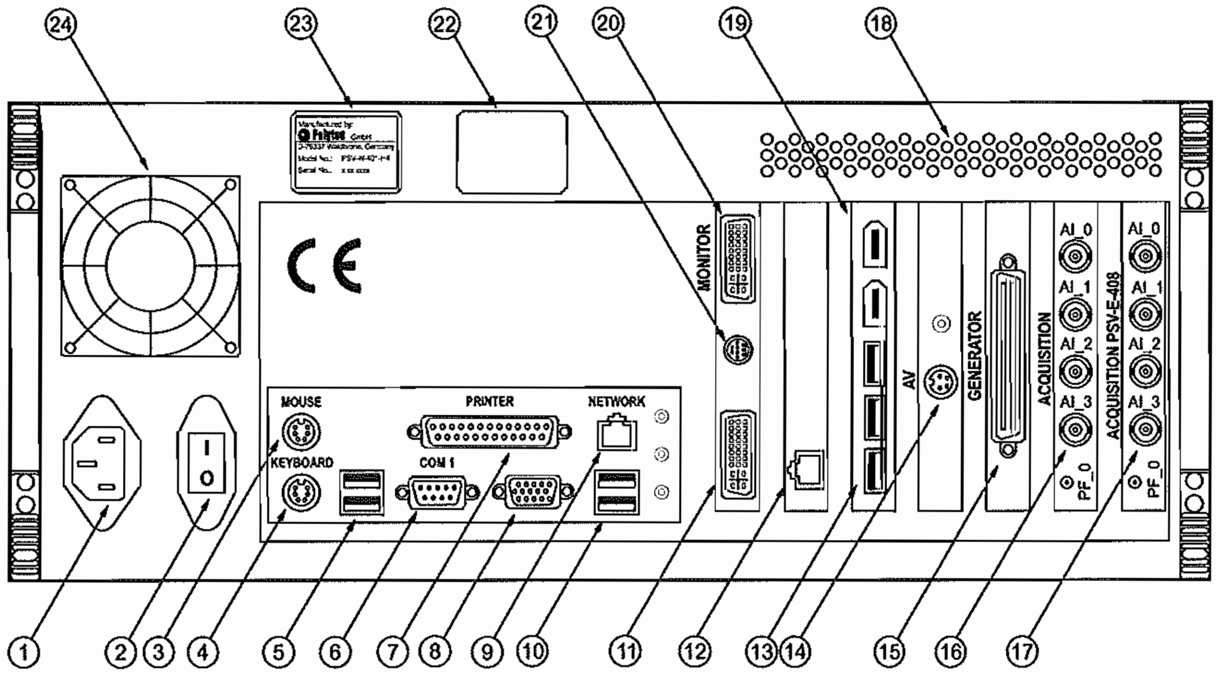

Figure 3.8: Rear view of the PC for the PSV model -H4

1 **Mains connection** (socket for standard power cord)

The mains voltage input is designed to be a wide range input (refer also to SECTION 3.2).

2 **Mains switch**

The mains switch disconnects the PC from the mains (position O) and is used to switch it off in case of danger.

CAUTION !

Danger from mishandling ! - Always connect up all connecting cables before you switch on the PC!

3 Connector **MOUSE** (6-pin circular jack)

4 Connector **KEYBOARD** (6-pin circular jack)

5 **USB** interface (Universal Serial Bus, type A)
Alternative connector for peripheral devices such as mouse, keyboard, etc. or to connect the hardlock to release the software

6 Serial interface **COM1** (9-pin Sub-D plug)

7 Parallel **PRINTER** connector (25-pin Sub-D jack)
Connector for the printer and the hardlock to release the software

8 MONITOR connector (15-pin Sub-D jack)

9 Connector **NETWORK**
For connecting up to an ethernet network

10 **USB** interface (Universal Serial Bus, type A)
Connector for the USB cable from the junction box to control the PSV via the software

11 Monitor connector (DVI jack)
Connector for an additional TFT monitor

12 Network connector
To connect the WLAN Access Point of the optional PSV-A-PDA

13 **USB** interface (Universal Serial Bus, type A)
Additional alternative connectors for peripheral devices such as mouse, keyboard, etc. or to connect the hardlock to release the software

14 **AV** connector (S-Video jack)
Connector for the video cable from the junction box to transmit the video signal

15 Connector **GENERATOR** of the internal function generator (SCSI-II type), only PSV-400-H4
Connector for the generator cable to the junction box to transmit the signal of the internal function generator

16 Connectors **ACQUISITION** for the data acquisition (BNC jacks and SMB jack)
Connectors for the data Acquisition cable from the junction box PSV-E-401 to transmit both measurements and trigger signals. You will find a detailed description of the connectors of the data acquisition board in the following.

NOTE !

Please make sure that you always connect the junction box **PSV-E-401** to these connectors !

17 Connectors **ACQUISITION PSV-E-408** for additional reference signals (BNC jacks and SMB jack), optional only PSV-400-H4

Connectors for the data Acquisition from the optional junction box PSV-E-408 to transmit the additional reference signals

> **NOTE !**
>
> Please make sure that you always connect the optional junction box **PSV-E-408** to these connectors !

18 Air vents

> **CAUTION !**
>
> **Danger from heat accumulation !** - To ensure sufficient cooling, these openings must kept free! The distance to the wall must be at least 50mm!

19 IEEE-1394 interface

20 MONITOR connector (DVI jack)

21 Video output (9-pin circular jack)

22 Instrument warning label

Label with technical data for the mains connection

23 Identification label

On the identification label you will find, among other things, the serial number of the instrument.

24 Cooling fan

> **CAUTION !**
>
> **Danger from heat accumulation !** - This opening must always be kept free to ensure sufficient cooling! The distance to the wall must be at least 50mm!

Data acquisition board for PC model -H4

The connectors of the data acquisition board PCI-4462 for the PC model -H4 are shown in FIGURE 3.9.

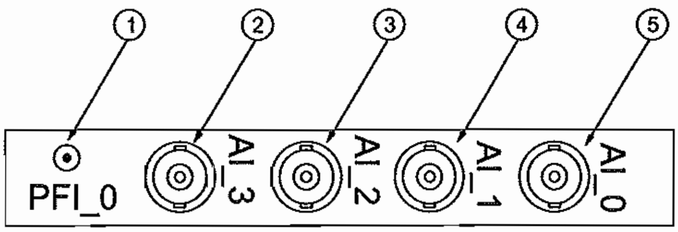

Figure 3.9: View of the data acquisition board PCI-4462

1 TTL input **PFI_0** (SMB jack)

TTL input for an external trigger signal

2 Analog input **AI_3** (BNC jack)

Analog voltage input for the reference signal

3 Analog input **AI_2** (BNC jack)
Analog voltage input for the reference signal

4 Analog input **AI_1** (BNC jack)
Analog voltage input for the reference signal

5 Analog input **AI_0** (BNC jack)
Analog voltage input for the vibrometer signal (Velocity)

Data acquisition board for PC model -B

The connections of the data acquisition board PCI-4461 are shown in FIGURE 3.10.

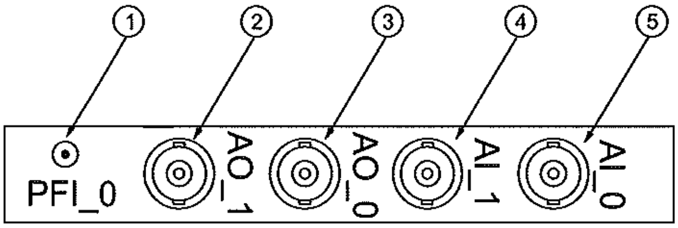

Figure 3.10: View of the data acquisition board PCI-4461

1 TTL input **PFI_0** (SMB jack)
TTL input for an external trigger signal

2 TTL output **AO_1** (BNC jack)
Synchronization pulse for the signal of the internal function generator. The output is only active with the corresponding option.

3 Analog output **AO_0** (BNC jack)
Analog voltage output for the signal of the internal function generator of the data acquisition board PCI-4461. The output is only active with the corresponding option.

4 Analog input **AI_1** (BNC jack)
Analog voltage input for the reference signal

5 Analog input **AI_0** (BNC jack)
Analog voltage input for the vibrometer signal (Velocity)

Back panel for the models -M2 and -M4

The back panel of the PC for the PSV models -M2 and -4 is shown in FIGURE 3.11. The order of the plug-in boards may vary from that shown in the picture.

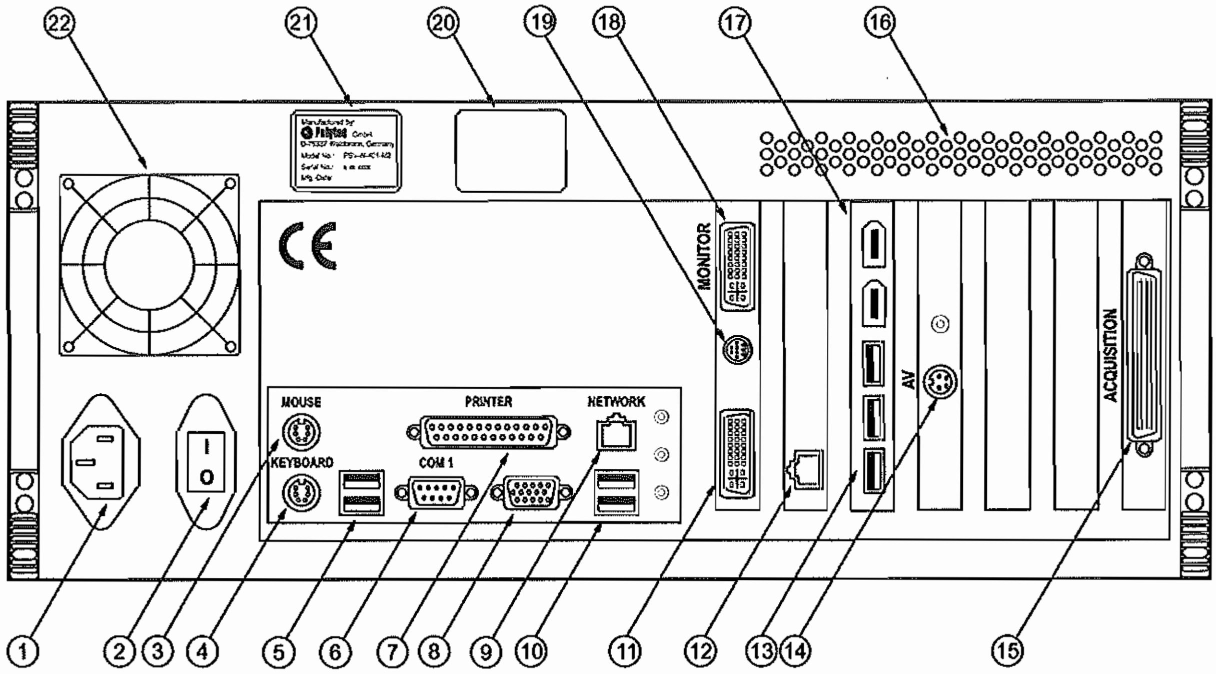

Figure 3.11: Rear view of the PC for the PSV models -M2 and -M4

1 **Mains connection** (socket for standard power cord)

The mains voltage input is designed to be a wide range input (refer also to SECTION 3.2.

2 **Mains switch**

The mains switch disconnects the PC from the mains (position O) and is used to switch it off in case of danger.

> **CAUTION !**
>
> **Danger from mishandling !** - Always connect up all connecting cables before you switch on the PC!

3 Connector **MOUSE** (6-pin circular jack)

4 Connector **KEYBOARD** (6-pin circular jack)

5 **USB** interface (Universal Serial Bus, type A)

Alternative connector for peripheral devices such as mouse, keyboard, etc. or to connect the hardlock to release the software

6 Serial interface **COM 1** (9-pin Sub-D plug)

7 Parallel **PRINTER** connector (25-pin Sub-D jack)

Connector for the printer and the hardlock to release the software

8 MONITOR connector (15-pin Sub-D jack)

9 Connector **NETWORK**
For connecting up to an ethernet network

10 **USB** interface (Universal Serial Bus, type A)
Connector for the USB cable from the junction box to control the PSV via the software

11 Monitor connector (DVI jack)
Connector for an additional TFT monitor

12 Network connector
To connect the WLAN Access Point of the optional PSV-A-PDA

13 **USB** interface (Universal Serial Bus, type A)
Additional alternative connectors for peripheral devices such as mouse, keyboard, etc. or to connect the hardlock to release the software

14 **AV** connector (S-Video jack)
Connector for the video cable from the junction box to transmit the video signal

15 Connector **ACQUISITION** for the data acquisition (SCSI-II type)
Connector for the acquisition cable from the junction box to transmit both measurement and trigger signals

16 **Air vents**

> **CAUTION !**
>
> **Danger from heat accumulation!** - To ensure sufficient cooling, these openings must kept free! The distance to the wall must be at least 50mm!

17 **IEEE-1394** interface

18 **MONITOR** connector (DVI jack)

19 Video output (9-pin circular jack)

20 **Instrument warning label**
Label with technical data for the mains connection

21 **Identification label**
On the identification label you will find, among other things, the serial number of the instrument.

22 **Cooling fan**

> **CAUTION !**
>
> **Danger from heat accumulation!** - This opening must always be kept free to ensure sufficient cooling! The distance to the wall must be at least 50mm!

Back panel for model -M2-20

The back panel of the PC for the PSV model -M2-20 is shown in FIGURE 3.12. The order of the plug-in boards may vary from that shown in the picture.

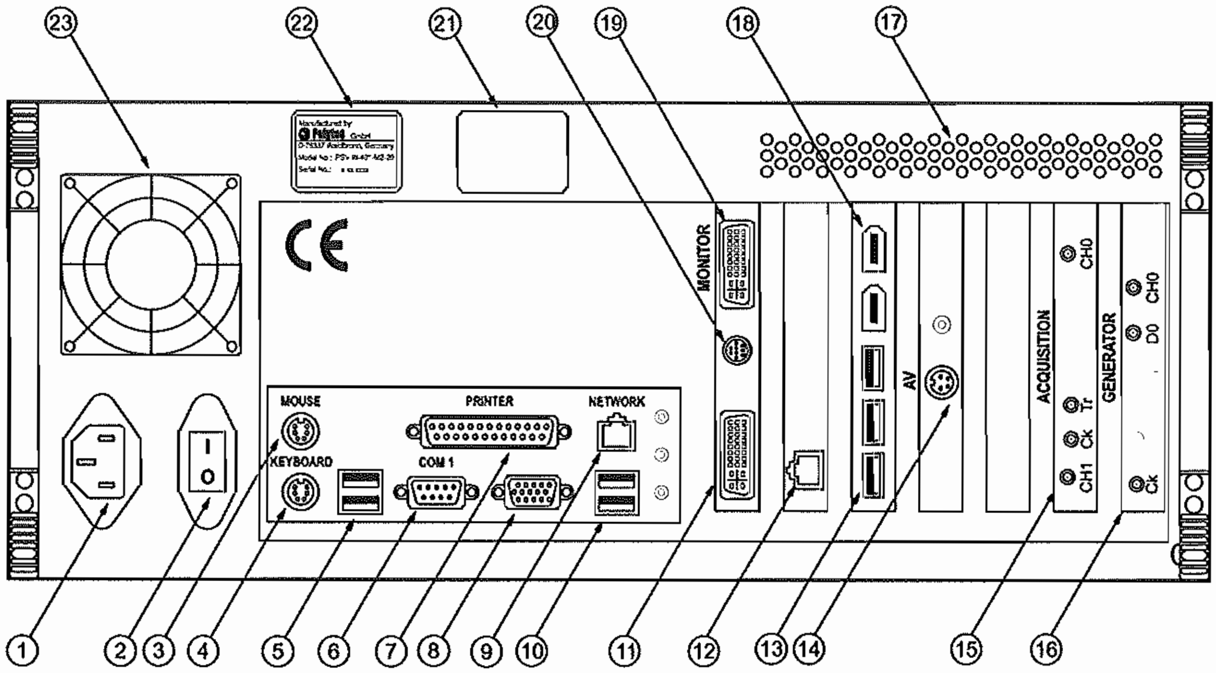

Figure 3.12: Rear view of the PC for the PSV model -M2-20

1 **Mains connection** (socket for standard power cord)

The mains voltage input is designed to be a wide range input (refer also to SECTION 3.2).

2 **Mains switch**

The mains switch disconnects the PC from the mains (position O) and is used to switch it off in case of danger.

> **CAUTION !**
>
> **Danger from mishandling !** - Always connect up all connecting cables before you switch on the PC!

3 Connector **MOUSE** (6-pin circular jack)

4 Connector **KEYBOARD** (6-pin circular jack)

5 **USB** interface (Universal Serial Bus, type A)

Alternative connector for peripheral devices such as mouse, keyboard, etc. or to connect the hardlock to release the software

6 Serial interface **COM 1** (9-pin Sub-D plug)

7 Parallel **PRINTER** connector (25-pin Sub-D jack)

Connector for the printer and the hardlock to release the software

8 MONITOR connector (15-pin Sub-D jack)

9 Connector **NETWORK**
For connecting up to an ethernet network

10 **USB** interface (Universal Serial Bus, type A)
Connector for the USB cable from the junction box to control the PSV via the software

11 Monitor connector (DVI jack)
Connector for an additional TFT monitor

12 **Network connector**
To connect the WLAN Access Point of the optional PSV-A-PDA

13 **USB** interface (Universal Serial Bus, type A)
Additional alternative connectors for peripheral devices such as mouse, keyboard, etc. or to connect the hardlock to release the software

14 **AV** connector (S-Video jack)
Connector for the video cable from the junction box to transmit the video signal

15 Connectors **ACQUISITION** for the data acquisition (SMB jack)
Connectors for the acquisition and generator cable ACQ/GEN 20MHz from the junction box PSV-E-401 to transmit both measurements and control signals. You will find a description of the connectors of the data acquisition board in the following section.

16 Connectors **GENERATOR** of the generator board (SMB jacks)
Connectors for the acquisition and generator cable ACQ/GEN 20MHz to the junction box PSV-E-401 to transmit the signal of the internal function generator. You will find a description of the connectors of the generator board in the following section.

17 **Air vents**

CAUTION !

Danger from heat accumulation ! - To ensure sufficient cooling, these openings must kept free! The distance to the wall must be at least 50mm!

18 **IEEE-1394** interface

19 **MONITOR** connector (DVI jack)

20 Video output (9-pin circular jack)

21 **Instrument warning label**
Label with technical data for the mains connection

22 **Identification label**
On the identification label you will find, among other things, the serial number of the instrument.

23 Cooling fan

> **CAUTION !**
>
> **Danger from heat accumulation !** - This opening must always be kept free to ensure sufficient cooling! The distance to the wall must be at least 50 mm!

Data acquisition board for PC model -M2-20

The connectors of the data acquisition board Spectrum MI.3025 for the PSV-400-M2-20 are shown in FIGURE 3.13.

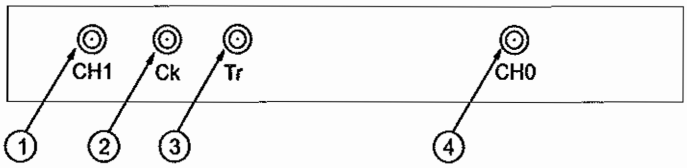

Figure 3.13: View of the data acquisition board for the PSV model -M2-20

1. Signal input **Ch 1** (SMB jack)
   Signal input for the reference signal
2. Signal output **Ck** (SMB jack)
   Output for the clock signal to synchronize the data acquisition board with the generator board
3. Signal input **Tr** (SMB jack)
   Signal input for an external trigger signal
4. Signal input **Ch 0** (SMB jack)
   Signal input for the velocity signal

Generator board for PC model -M2-20

The connectors of the generator board Spectrum MI.6030 for the PSV-400-M2-20 are shown in FIGURE 3.14.

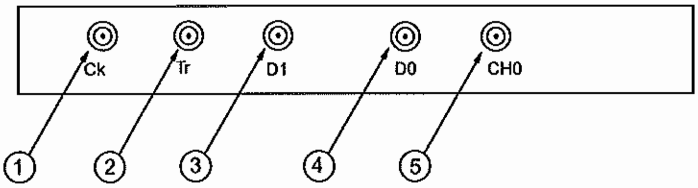

Figure 3.14: View of the generator board for the PSV model -M2-20

1 Clock input **Ck** (SMB jack)
  Input for the clock signal (Clock) to synchronize the generator board with the data acquisition board

2 Signal input **Tr** (SMB jack)
  Not active

3 Pulse output **D1** (SMB jack)
  Not active

4 Pulse output **D0** (SMB jack)
  Synchronization pulse for the signal of the internal function generator

5 Signal output **CH0** (SMB jack)
  Signal output of the internal function generator

3.3.5 Scanning Head

Front panel The front panel of the scanning head is shown in FIGURE 3.15.

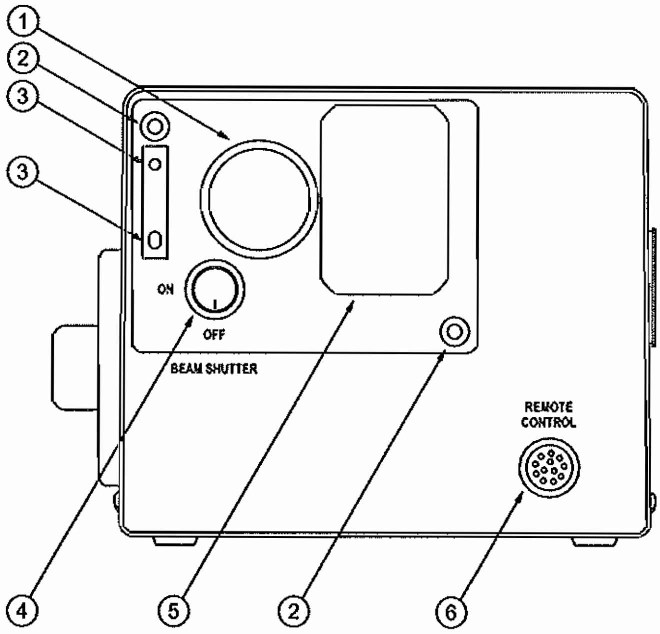

Figure 3.15: Front view of the scanning head

1 Front lens of the **video camera**

The video camera is controlled via the software as described in your software manual.

2 Mounting threads for the optional **close-up unit** PSV-A-410

The optional close-up unit is used for scanning small parts at short distance (refer to SECTION A.2).

3 Drill holes for mounting the optional **close-up unit**

4 Rotary knob **BEAM SHUTTER ON/OFF** for the beam shutter

The apertures for the laser beam and the video camera are closed if the rotary knob is turned counterclockwise until the mark points at OFF. Thus also the laser beam is blocked.

WARNING !

Danger from laser light ! - Only open the beam shutter when you are making measurements!

5 Laser beam **aperture**

Positioning and focusing the laser beam is controlled via the software described in your software manual. The laser beam can also be positioned and focused using the hand set PSV-Z-051 as described in SECTION 5.5 and SECTION 5.6.

WARNING !

Danger from laser light ! - Avoid looking directly into the laser beam with the naked eye or with the aid of mirrors or optical instruments!

6 REMOTE CONTROL **connectors** for the hand set PSV-Z-051 (12-pin circular jack)

The hand set is used for positioning and focusing the laser beam (refer to SECTION 5.5 and SECTION 5.6).

Back panel

The back panel of the scanning head is shown in FIGURE 3.16.

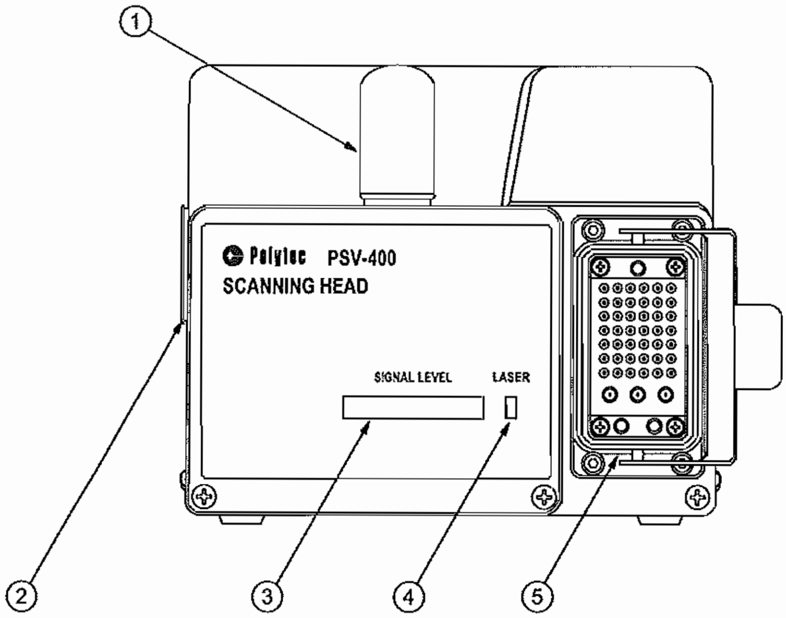

Figure 3.16: Rear view of the scanning head

1 **Transport handle**

2 Cover for the optional **geometry scan unit** PSV-A-420

The scanning head with geometry scan unit is described in detail in SECTION A.1.

3 **SIGNAL LEVEL** display

The length of the bar is a measure of the amount of light scattered back from the measurement surface.

4 **LASER** LED

The LED lights up when the scanning head is connected up correctly to the junction box and the laser is switch on (key switch on the controller is turned to position I). The LED indicates that the laser is active, even if the beam shutter is closed (refer to SECTION 5.3).

5 **Main connection** (industrial-style)

Connector for the umbilical cable to the junction box

View from the bottom The view from the bottom of the scanning head is shown in FIGURE 3.17.

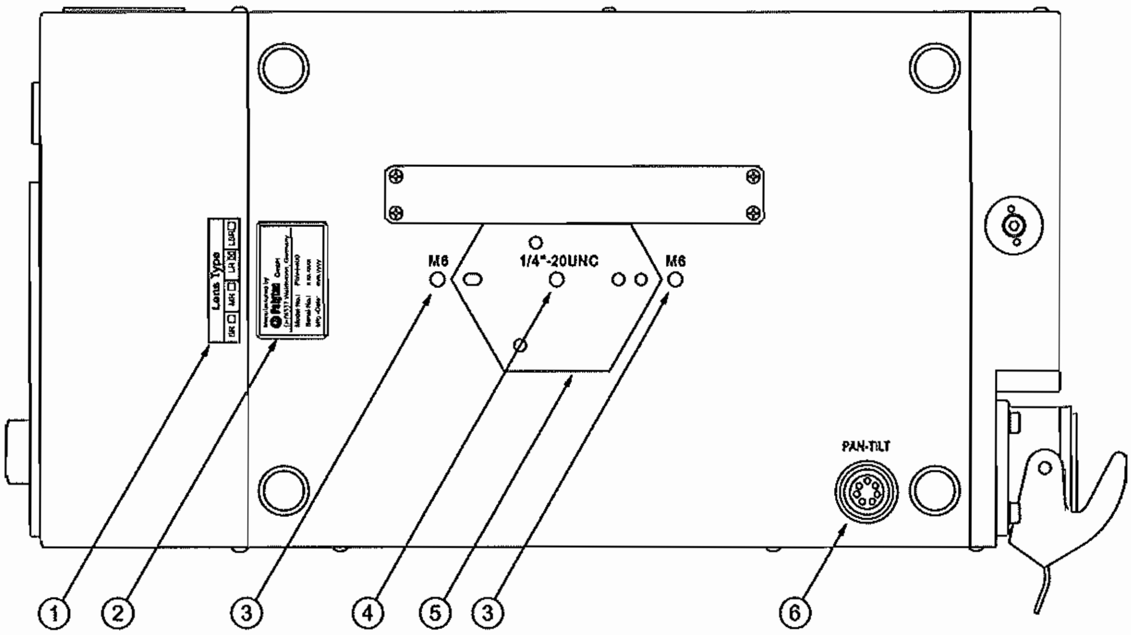

Figure 3.17: Bottom view of the scanning head

1 **Label for the front lens model**

On this label, it is marked which front lens model is installed.

2 **Identification label**

On the identification label you will find, among other things, the serial number of the instrument.

3 Mounting threads **M6**

Using these two mounting threads, the scanning head can be mounted on adapter plates, e.g. for mounting on the as an option pan-tilt stage PSV-A-T11 (refer to SECTION 3.4.1) or the optional test stand PSV-A-T18 (refer to SECTION A.3). You will find the dimensions of the mounting threads in the technical drawing in SECTION 7.5.

> **NOTE !**
>
> The mounting screws of the scanning head have to be tighten only with maximal 1.5Nm otherwise the laser beam interference of the scanning head with the geometry scan unit can be disturbed!

4 Mounting thread **1/4"-20UNC**

Using the mounting thread, the scanning head can be mounted on stable camera tripods with thread basing on inch-system.

5 Mounting threads for hexagonal **quick release plate**

Using these mounting threads, the hexagonal quick release plate can be mounted on the scanning head, e.g. for mounting the scanning head on the tripod with fluid stage VIB-A-T02.

6 PAN-TILT **connector** for the optional pan-tilt stage (7-pin circular jack)

Connector for the connecting cable to the optional pan-tilt stage PSV-A-T11 to control the pan-tilt stage via the software

3.4 Installation

3.4.1 Assembly

Scanning head The scanning head is mounted on either a tripod with fluid stage (VIB-A-T02) or a heavy duty tripod with motorized pan-tilt stage (PSV-A-T11, optional). The heavy duty tripod can also be mounted on a trolley (on request). The scanning head mounted on the tripod with fluid stage is shown in FIGURE 3.18.

Figure 3.18: Scanning head mounted on the tripod with fluid stage

Before attempting to mount the scanning head, all locking mechanisms of the trolley and the tripod, particularly screws, should be checked to make sure they are tight. A loose screw may cause the stand to be unstable and possibly collapse.

NOTE !

It is best to carry out the following assembly when someone is there to help you!

Tripod with fluid stage (VIB-A-T02)

If your PSV is equipped with a tripod with fluid stage, you must proceed with the assembly as follows:

1. Assemble the tripod as described in the assembly instructions provided by the manufacturer MANFROTTO.
2. Then mount the fluid stage as described in the assembly instructions providing by the manufacturer MANFROTTO.
3. Open the locking mechanism on the fluid stage by simultaneously pressing the safety latch and opening the safety lever.
4. A suitable hexagonal quick release plate has been pre-mounted on the scanning head. Use this plate to position the scanning head on the fluid stage.

   The safety lever clicks into place automatically.
5. Ensure that the quick release plate is attached all the way around. This needs to be done before the scanning head is ready to use.
6. Whenever you want to remove the scanning head from the fluid stage, one person should hold the scanning head while the second person opens the safety lever.
7. Keep the assembly instructions for the tripod and the fluid stage in a safe place.

Tripod with pan-tilt stage PSV-A-T11 (optional)

If your PSV is equipped with a heavy duty tripod with pan-tilt stage, you must proceed with the assembly as follows:

1. Unpack the pan-tilt stage and check it for external damage (scratches, loose screws, etc.).
2. Check the contents of the assembly kid:

   1 Adapter plate with 3 Allen screws M6x16
   1 Connector box with 4 Allen screws M8x40
   3 Allen screws M8x16 with washers
   1 Mounting plate with 2 countersunk screws M6x16
   2 Allen screws M6x16 with washers
   1 Allen key size 4mm
   1 Allen key size 5mm
   1 Allen key size 6mm

CAUTION !

Danger from mounting error! - Make sure that the screws are always tightened to ensure that the system is both stable and functions accurately!

3. Attach the mounting plate on the underside of the scanning head with 2 countersunk screws M6x16. To do this use the Allen key size 4mm.

CAUTION !

Danger from mounting error! - Make sure that the mounting plate is correctly aligned! The FRONT labeled side of the plate has to be mounted in the direction of the front panel of the scanning head as shown in FIGURE 3.19.

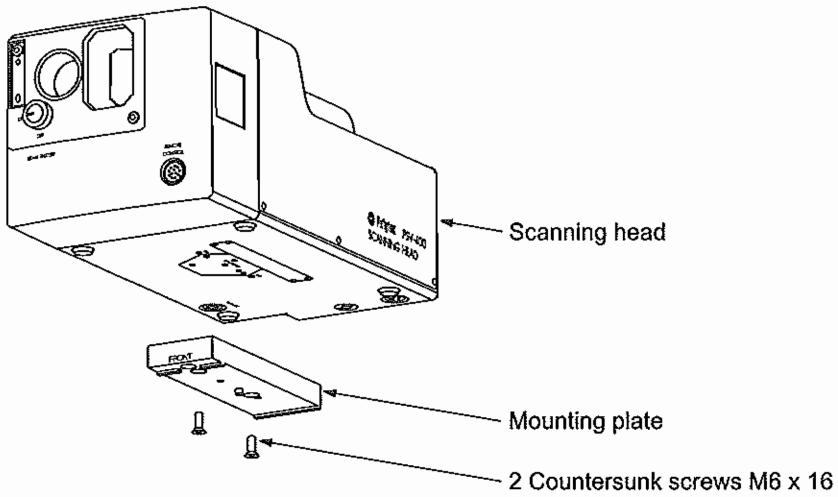

Figure 3.19: Fixing the mounting plate on the scanning head

4. Unpack the tripod and check it for external damage (scratches, loose screws, etc.).

5. Assemble the tripod as described in the assembly instructions provided by the manufacturer MANFROTTO.

6. Unscrew the protective cap, which is located on the central thread of the tripod.

7. Unscrew the rotary handle on the underside of the tripod and remove the tripod plate.

8. Unscrew the three set screws on the underside of the tripod plate and keep the set screws in case you may need them at a later date.

9. Put the tripod plate onto the tripod again and screw in the plate with the rotary handle. Pay attention to the horizontal alignment of the tripod plate.

10. Now mount the adapter plate on the top of the tripod plate using 3 Allen screws M6x16 as also shown in FIGURE 3.20.

NOTE !

Ensure that the rotary handle on the underside of the tripod is **always** tightened securely.

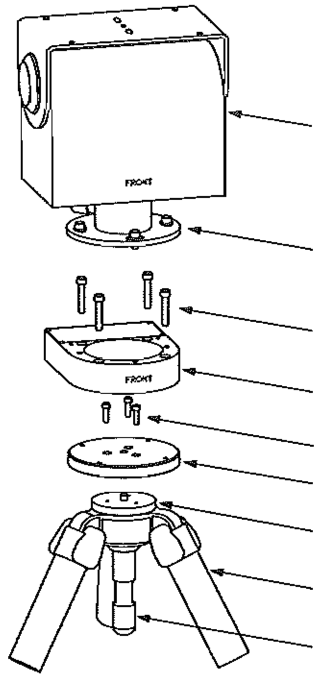

Figure 3.20: Mounting the pan-tilt stage on the tripod

11. Screw the connector box on the adapter plate using 4 Allen screws M8x40. To do this use the Allen key size 6mm.

12. Fix the pan-tilt stage on the connector box using 3 Allen screws M8x16 and the washers.

> **CAUTION !**
>
> **Danger from mounting error!** - Make sure that the pan-tilt stage is aligned correctly to the connector box! The FRONT labeled sides have to be mounted in the same direction.

13. Then mount the scanning head with its mounting plate on the pan-tilt stage using 2 Allen screws M6x16 and the washers as shown in FIGURE 3.21.

> **CAUTION !**
>
> **Danger from mounting error!** - Make sure that the FRONT labeled sides of the components are mounted in the direction of the front panel of the scanning head!

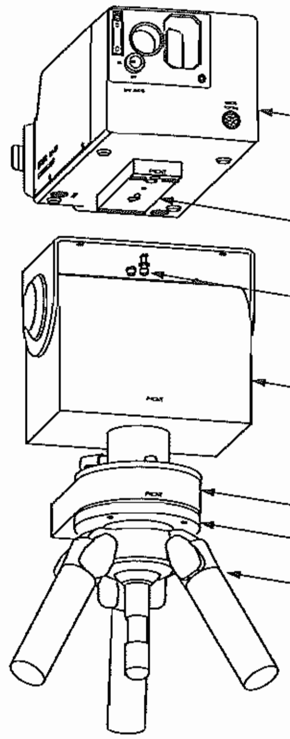

Figure 3.21: Mounting the scanning head on the pan-tilt stage

14. Keep the assembly instructions for the tripod and the pan-tilt stage in a safe place.

For cabling the pan-tilt stage, refer to SECTION 3.4.2.

System cabinet PSV-A-010 (optional)

You receive the system cabinet PSV-A-010 with all system components ready assembled and cabled. To unpack the system cabinet, please proceed as follows:

1. Remove the ramp from the packaging and place it in front of the pallet.
2. Open the packaging, remove the whole damping material from inside and pull carefully the packaging upward away.

   You can now roll the system cabinet of the pallet via the ramp and move of to the measurement location.

For the assembly of the system cabinet you proceed as follows:

3. Set up the system cabinet at the measurement location.

> **CAUTION !**
>
> **Danger from mishandling !** - Do not split up the two component parts without removing the cabling inside !

Inside the front cover of the PSV-A-010, there are holding devices for the keyboard and the mouse. Inside the rear cover, there are holding devices for one umbilical cable.

4. Demount the front cover of the PSV-A-010 with great care by turning up the wing screws and unfixing the locking hooks.
5. Open the velcro strips inside the front cover and put the keyboard and the mouse onto the table top.
6. Demount the rear cover of the PSV-A-010 with great care by turning up the wing screws and unfixing the locking hooks.
7. Open the velcro strips inside the rear cover and take out the umbilical cable.

Demount the front and the rear cover of the PSV-A-010 system cabinet extension by turning up the wing screws and unfixing the locking hooks.

> **CAUTION !**
>
> **Danger from heat accumulation !** - The PSV may only be operated in the system cabinet if the cover of the system cabinets are removed. Otherwise generation of heat can cause damages in the instruments!

The position of the individual system components in the cabinet is shown in FIGURE 3.22.

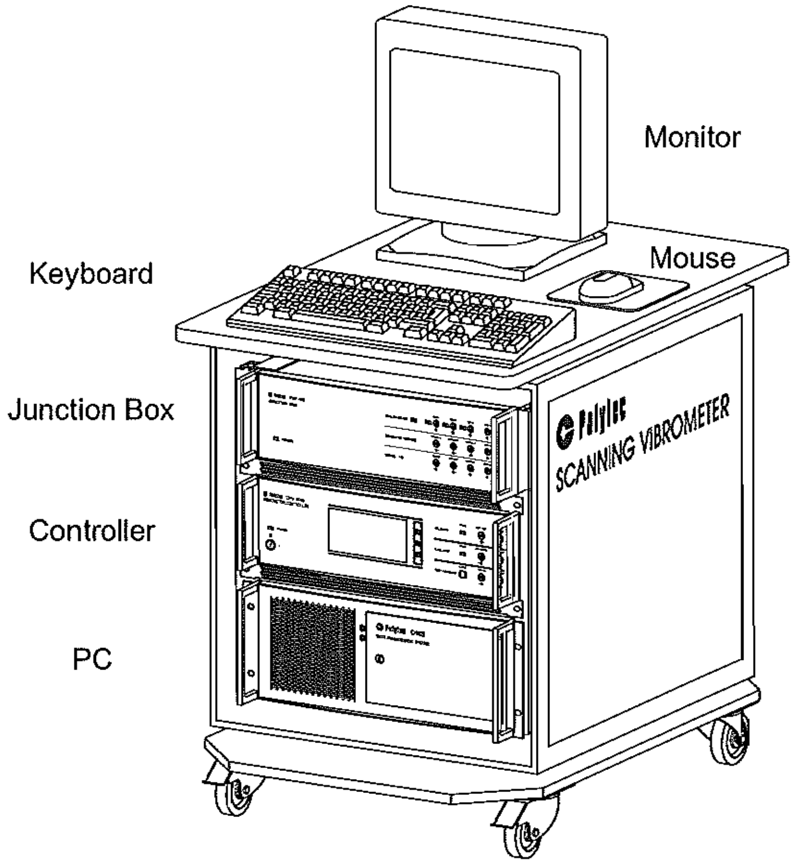

Figure 3.22: Position of the PSV components in the system cabinet

If you order the system cabinet, you have to build in the components yourself into the system cabinet. To do so, proceed as follows:

1. Undo the housing feet of the system components and keep the housing feet and the screws in a safe place.
2. Place the PC at the bottom.
3. Insert the controller above the PC.
4. If applicable, insert the optional junction box PSV-E-408 instead of the ventilation sheet above the controller (only PSV-400-H4).
5. Insert the junction box PSV-E-401 above the controller.
6. Fix all front panels with the screws provided.
7. Place the other system components on the system cabinet as shown in FIGURE 3.22.

All system components should be mounted correctly now. Carry out the cabling of the system components as described in SECTION 3.4.2.

> **CAUTION !**
>
> **Danger from electrical current!** - Always unplug all BNC cables from the front panel before you close the system cabinet with the cover!

3.4.2 Cabling

The individuals steps on cabling the PSV are described in the following. The complete cabling is also shown in FIGURE 3.23 to FIGURE 3.29. All connections must be easy to plug in. If not, check the plugs for bent contact pins to avoid serious damage being incurred. Secure the connections correspondingly. Should any problems occur in cabling, please contact your local Polytec representative.

> **CAUTION !**
>
> **Danger from mishandling !** - Always connect all components to each other before plugging in the mains cables!

Controller <=> junction boxPSV-E-401

1. To operate the controller via the software, plug the **RS-232(X)** cable into the Sub-D connector RS 232 on the back of the controller and into the Sub-D connector RS 232 on the back of the junction box.
2. Plug the **interferometer** cable into the Sub-D jack SENSOR on the back of the controller and into the Sub-D jack OFV-5000 on the back of the junction box.
3. For transmission of the velocity signal, plug the **BNC** cable into the BNC jack VELOCITY OUTPUT on the front of the controller and into BNC jack VELO on the front of the junction box.

Reference signal

4. If required, connect the reference signal to the BNC jack REF 1 on the front of the junction box.
5. **PSV-400-H4, -M4:** You can connect up to two additional reference signal to the BNC jack REF 2 and REF 3 on the front of the junction box. Digital function generators, for example the HP 33120, should be preferably connected to REF 1 to prevent Alias effects.

External trigger

6. If required, connect the external trigger signal to the BNC jack TRIG IN on the front of the junction box.

Internal function generator

7. If required, the signal of the internal function generator is available at the BNC jack SIGNAL 1 on the front of the junction box (optional for PSV-400-B).
8. **PSV-400-H4:** If required, three additional signals of the internal function generator are available at the BNC jacks SIGNAL 2 to SIGNAL 4 on the front of the junction box.
9. If required, the synchronization pulse of the generator signal is available at the BNC jack SYNC on the front of the junction box (optional for PSV-400-B).

Acoustic gate unit

10. If applicable, connect the as an option acoustic gate unit PSV-A-430 to the BNC jack GATE IN on the back of the junction box.

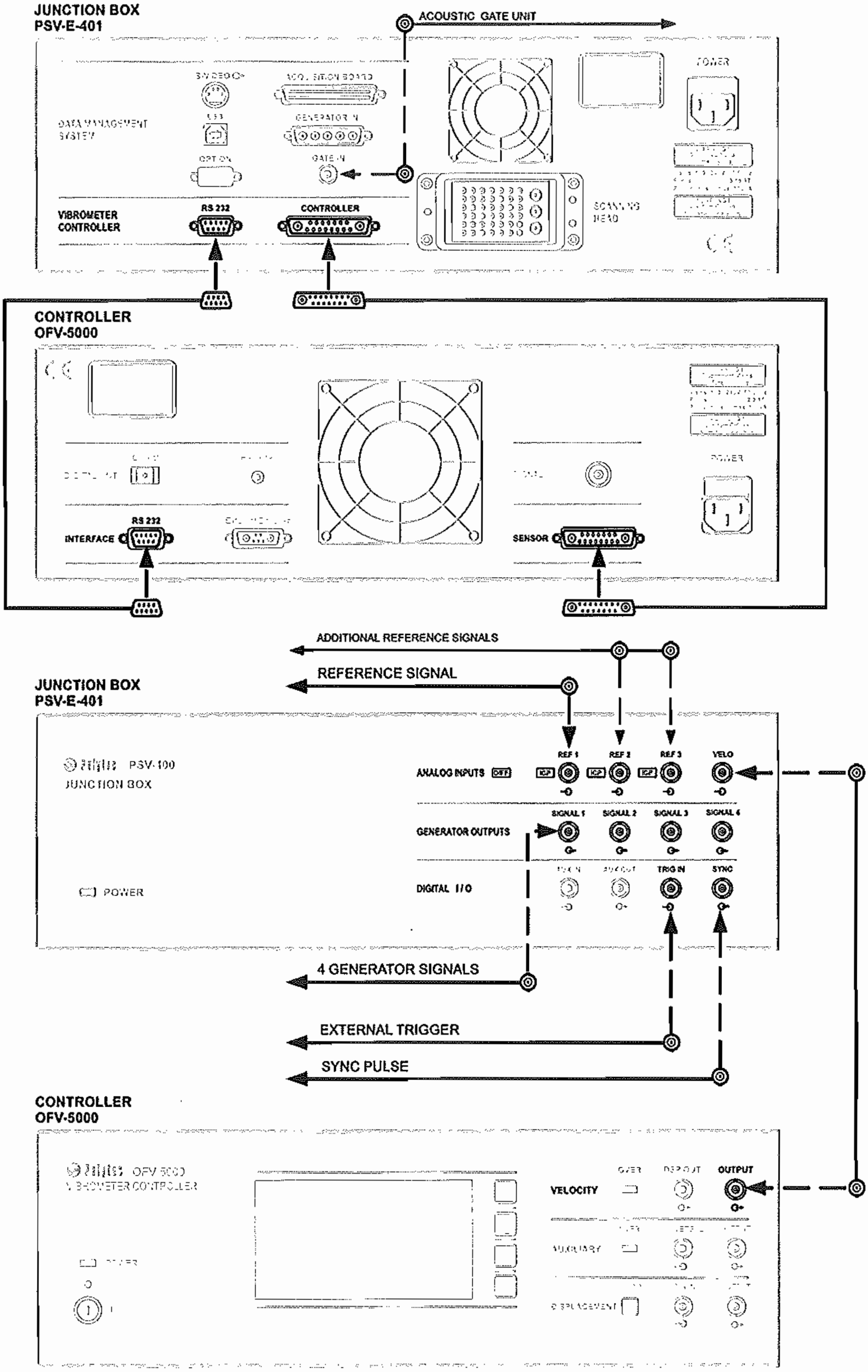

Figure 3.23: Cabling of the controller

Junction box PSV-E-401 <=> scanning head

11. The umbilical cable has both a jack with a straight cable exit and a jack with a cable exit on the side. The cabling can be selected freely depending on the way the scanning head has been mounted. Plug the **Umbilical** cable into the industrial-style connector SCANNING HEAD on the back of the junction box and into the industrial-style connector on the back of the scanning head.

Junction box PSV-E-401 <=> PC

12. To control the PSV via the software, plug the **USB** cable into the USB interface on the back of the junction box and into the USB interface on the back of the PC.

13. Plug the **S-Video** cable into the BNC jack S-VIDEO on the back of the junction box and via the adapter cable into the circular jack AV on the back of the PC.

> **CAUTION !**
>
> **Danger from mounting error !** - Plug in the SCSI connector with great care at the right angles so as not to damage them !

14. **PSV-400-H4:** Plug the acquisition cable **Acquisition** into the SCSI connector ACQUISITION BOARD on the back panel of the junction box and into the appropriate BNC jacks ACQUISITION (AI_3, AI_2, AI_1 and AI_0) and SMB jack (PFI_0) on the back of the PC.

15. **PSV-400-B**: Plug the acquisition cable **Acquisition** into the SCSI connector ACQUISITION BOARD on the back panel of the junction box and into the appropriate BNC jacks ACQUISITION (AO_1, AO_0, AI_1 and AI_0) and SMB jack (PFI_0) on the back of the PC.

16. **PSV-400-H4, -B:** Plug the **Generator** cable into the connector GENERATOR IN on the back of the junction box and into the SCSI connector GENERATOR on the back of the PC.

17. **PSV-400-M2, -M4:** Plug the acquisition cable **Acquisition** into the SCSI connector ACQUISITION BOARD on the back panel of the junction box and into the SCSI connector ACQUISITION on the back of the PC.

18. **PSV-400-M2-M20**: Plug the acquisition and generator cable **ACQ/GEN 20MHz** into the connector GENERATOR IN on the back of the junction box and into the corresponding SMB connectors ACQUISITION and GENERATOR on the back of the PC.

> **NOTE !**
>
> When cabling, pay attention to the designations of the cable ends of the acquisition and generator cable ACQ/GEN 20MHz! Thereby the cable end ACQ-CH0 is plugged into the CH0 jack of the data acquisition board and the GEN-CH0 is plugged into the CH0 jack of the generator board.

PC

19. Connect the keyboard to the circular jack KEYBOARD on the back of the PC.

20. Connect the mouse to the circular jack MOUSE on the back of the PC.

21. Connect the monitor cable to the monitor and to the jack MONITOR on the back of the PC.

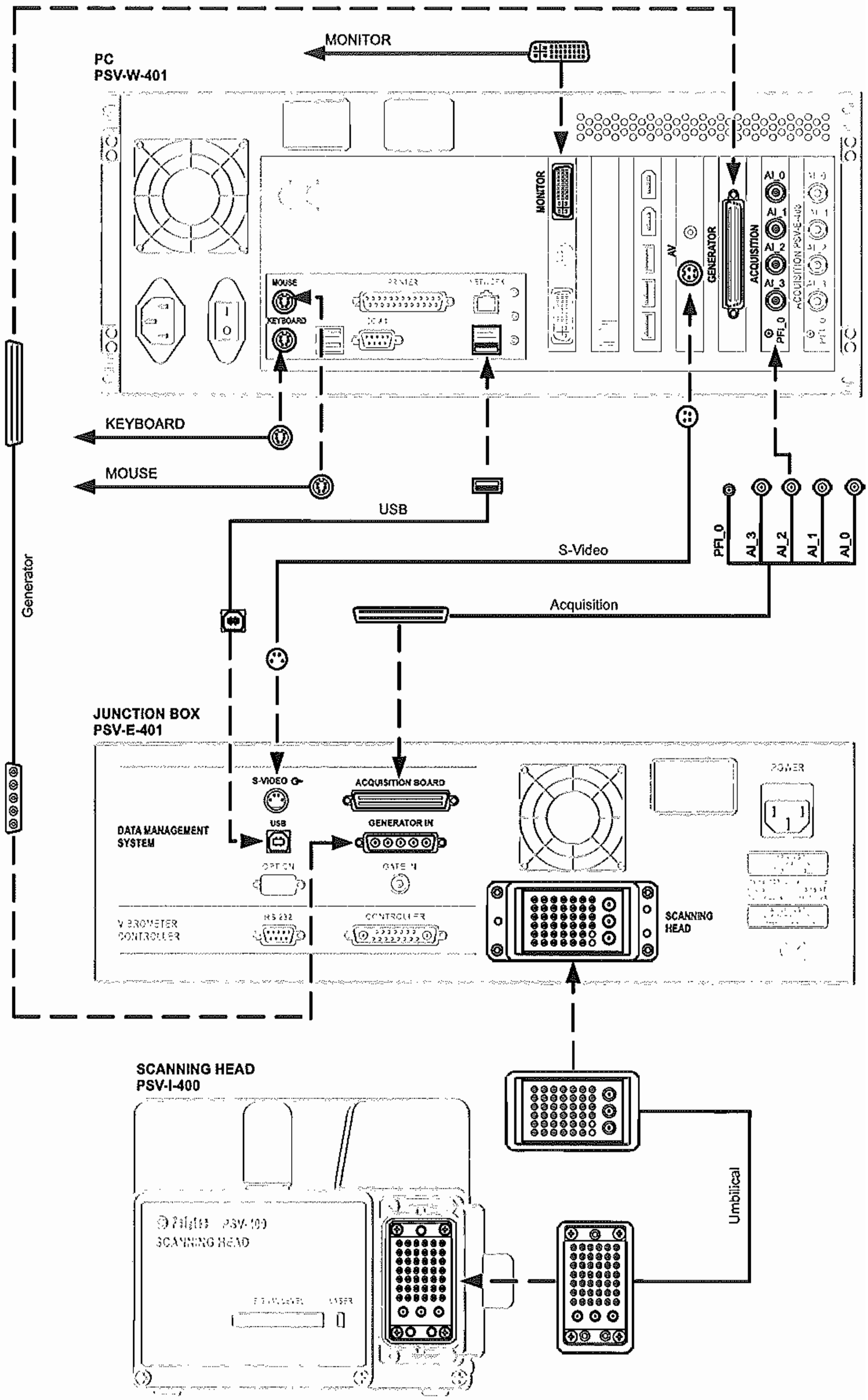

Figure 3.24: Cabling of the junction box (PSV-400-H4)

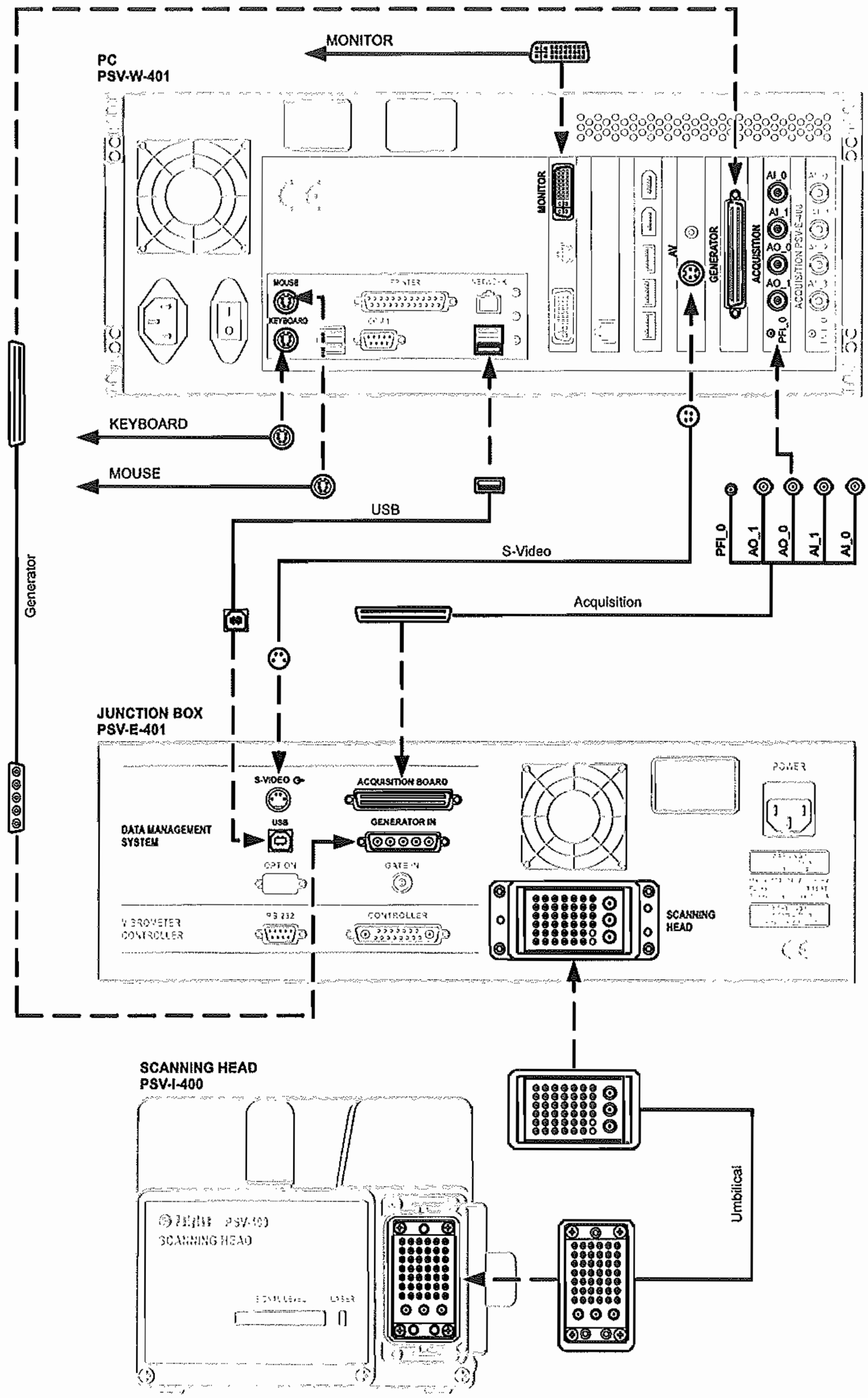

Figure 3.25: Cabling of the junction box (PSV-400-B)

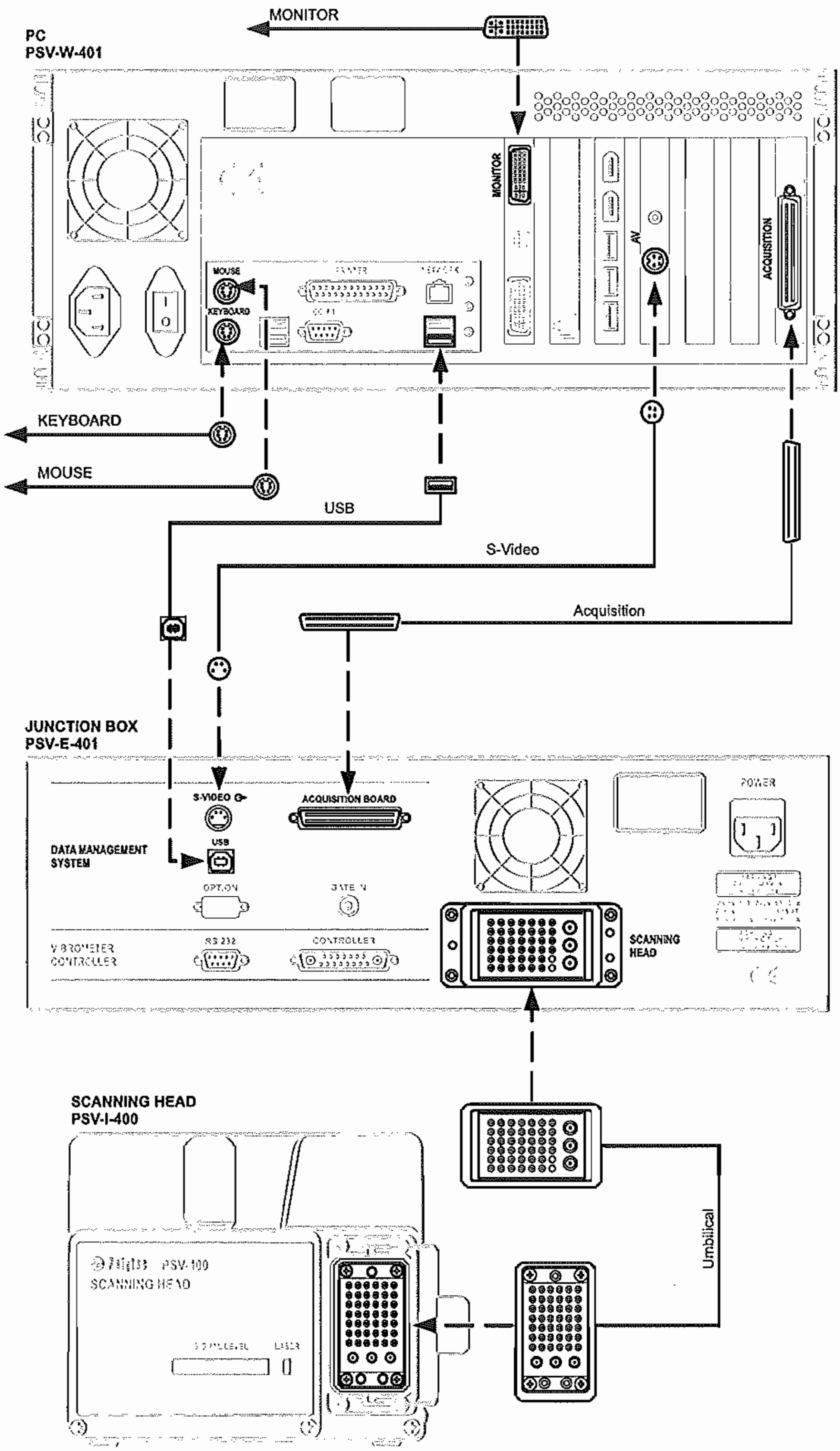

Figure 3.26: Cabling of the junction box (PSV-400-M2 and -M4)

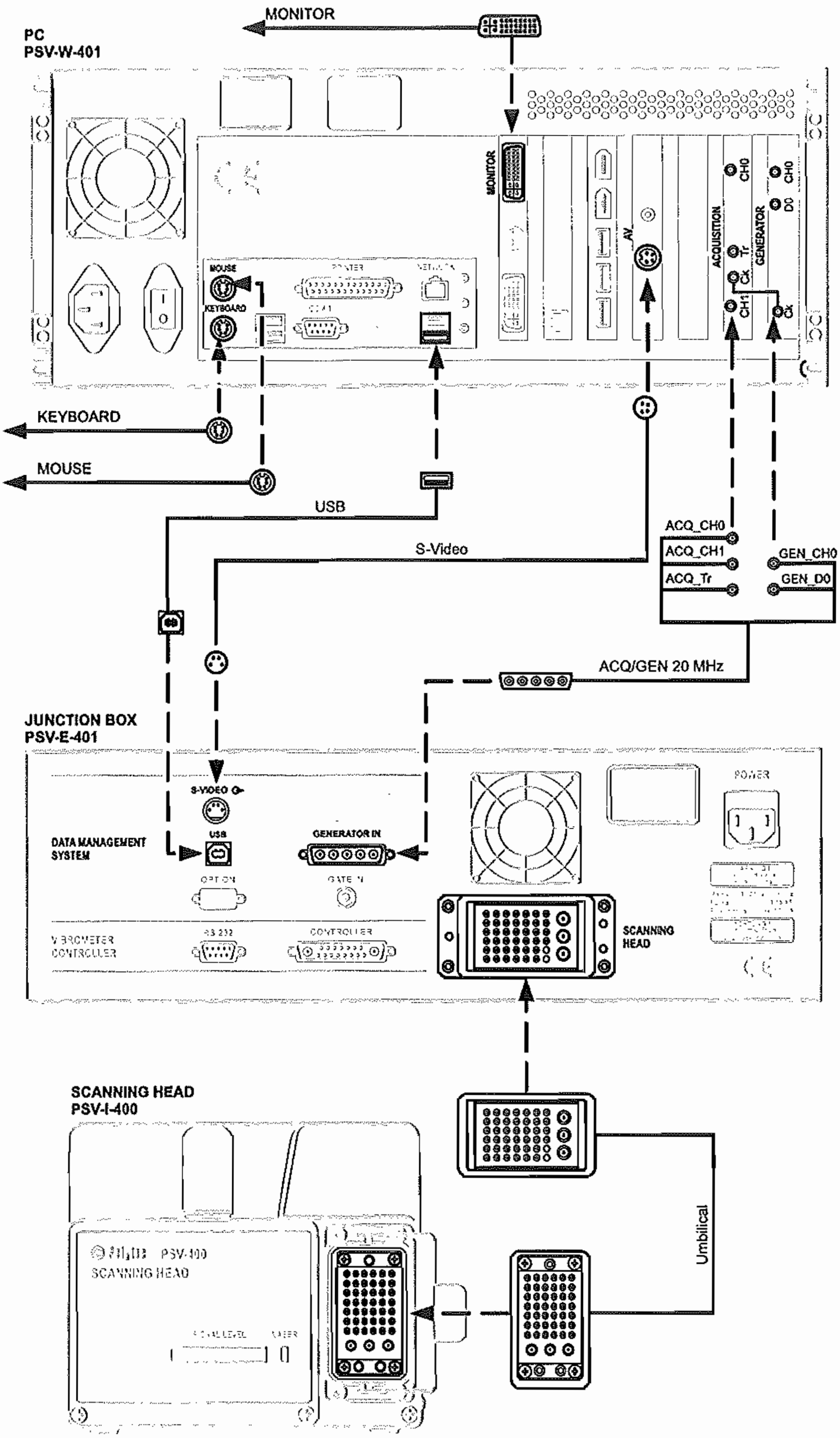

Figure 3.27: Cabling of the junction box (PSV-400-M2-20)

22. **PSV-400-M2-20:** Plug the SMB-SMB connecting cable into both SMB connectors Ck of the data acquisition board ACQUISITION and of the generator board GENERATOR on the back of the PC.

Junction box PSV-E-408 <=> PC

23. **PSV-400-H4:** Plug the optional acquisition cable **Acquisition** into the SCSI connector ACQUISITION BOARD on the back panel of the optional junction box PSV-E-408 and into the appropriate BNC jacks ACQUISITION PSV-E-408 (AI_3, AI_2, AI_1 and AI_0) and SMB jack (PFI_0) on the back of the PC.

> **NOTE !**
>
> Please pay attention that there are two data acquisition board installed in your PC. Connect the junction box **PSV-E-408 only** to the connectors ACQUISITION PSV-E-408 as you obtain unusable data !

24. Plug the USB cable into the USB interface on the back of the junction box and into a USB interface on the back of the PC.

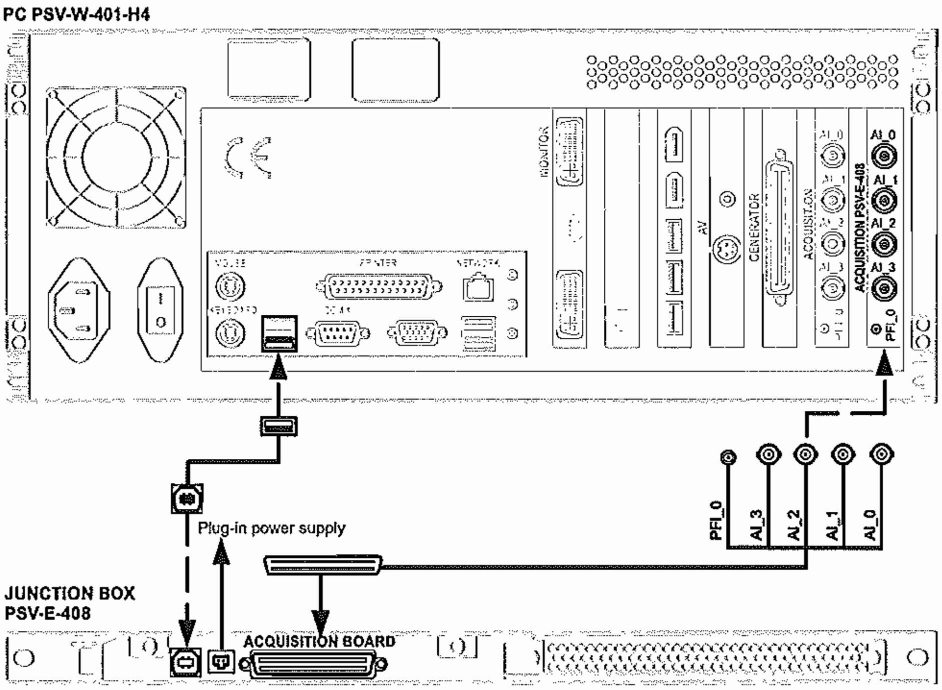

Figure 3.28: Cabling of the junction box PSV-E-408

Hand set

25. If required, connect the hand set PSV-Z-051 on the circular jack REMOTE CONTROL on the front of the scanning head.

> **CAUTION !**
>
> **Danger from mishandling!** - Connect the hand set PSV-Z-051 only when the controller is switched off.

26. If applicable, plug the network cable of the WLAN Access Point into the left of the two jacks NETWORK on the back of the PC to operate the optional hand set PSV-A-PDA.

Pan-tilt stage

27. If applicable, plug the **Scanning Head** cable of the connector box of the optional pan-tilt stage PSV-A-T11 into the circular jack PAN-TILT on the underside of the scanning head.

28. Plug the **Pan-Tilt** connecting cable from the connector box of the pan-tilt stage into the circular jack on the pan-tilt stage.

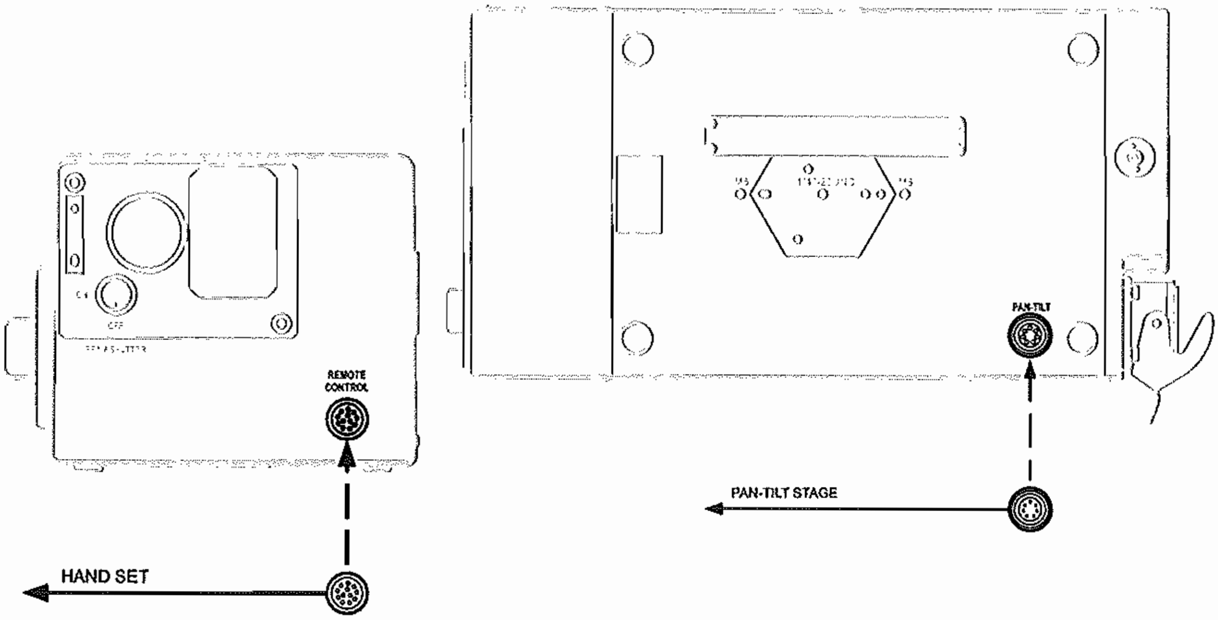

Figure 3.29: Cabling of the scanning head

Mains connection

To prevent ground loops, connect all mains cables of the measurement system to the same earthed socket.

29. Connect up all components (controller, junction box, PC and monitor) with the mains cables to a multiple socket.

30. Connect up the multiple socket with the extension cable to an earthed socket.

31. If applicable, connect the plug-in power supply to the junction box PSV-E-408 and to the same multiple socket.

32. If applicable, connect the mains cable to the back of the WLAN Access Point of the optional hand set PSV-A-PDA and to the same multiple socket.

33. If applicable, connect up the mains cable on the connector box of the pan-tilt stage and to the same multiple socket.

> **CAUTION !**
>
> **Danger from mishandling !** - Always check the setting of the voltage selector on the connector box of the pan-tilt stage before connecting to the mains!

The PSV is installed completely now. Carry out a functional test as described in SECTION 3.5.

3.5 Functional Test

For an initial functional test of the PSV, you proceed as follows:

Preparing

1. Install and cable the PSV as described in SECTION 3.4.
2. Please ensure that the key switch on the controller is in position O and that the beam shutter on the scanning head is closed (positions OFF).
3. Position the scanning head roughly such as that its laser beam aperture points to the test surface.

Switching on

4. Switch the controller on by turning the key switch to position I.

   The LED POWER on the front of the controller lights up. Providing all connecting cables have been installed correctly, the LED POWER on the front of the junction box and the LED LASER on the scanning head light up. Laser light is not yet emitted as the beam shutter is still closed.

5. Switch on the PC, start the PSV software and change to the Acquisition Mode as described in your software manual.

   On changing to the Acquisition Mode, control of the system by the software is activated. If you want change the settings on the front panel of the controller, you receive an appropriate message on the controller (keyboard is locked by interface control).

6. Before now opening the beam shutter, remember the information on laser safety provided in SECTION 1.2!
7. Open the beam shutter on the scanning head.

   The laser beam is now emitted from the scanning head.

Test

8. Test the function of the scanning head (position and focus of the laser beam, zoom and focus of the video camera, optional movement of the pan-tilt stage), as described in your software manual.

9. Put a matt white test surface such as a piece of paper, at approximately 50 cm from the front panel of the scanning head in the beam path.

10. Focus the laser beam on the test surface.

    The signal level display will light up to show that the scanning head and the input section of the controller are working correctly.

If this functional test was successful, you can now make measurements with the PSV as described in CHAPTER 4 and CHAPTER 5. Remember that the PSV reaches its optimal properties after a warm-up period of approx. 20 minutes.

If your PSV does not perform as described above, read through the information on fault diagnosis provided in CHAPTER 6, if necessary, contact your local Polytec representative.

Direction convention

The following direction convention applies to the output signals:

A movement **towards** the scanning head is seen as being **positive**. In this case the velocity output supplies a positive voltage and the displacement output an increasing voltage.

4 Making Measurements

Data acquisition and storage for the PSV is fully controlled via the software. A live video image of the object is displayed on the monitor and automatic scan sequences are defined directly on the live video image of the object. All acquisition properties are set in the software. For evaluation, the acquired data is overlaid directly onto recorded video image. Data can also be exported to various software packages e.g. for modal analysis.

4.1 Start-up the PSV

To make a measurement with the PSV you proceed as follows:

Setup

1. Please ensure that the key switch on the controller is in position O and that the beam shutter on the scanning head is closed.
2. Position the scanning head roughly such as that its laser beam aperture points in the direction of to the object to be measured. If possible set the scanning head up at an optimal stand-off distance to the object to be measured. You will find information about the optimal stand-off distance in SECTION 4.3.

Switching on

3. Switch the controller on by turning the key switch to position I.

   The LED POWER on the front of the controller lights up. Providing all connecting cables have been installed correctly, the LED POWER on the front of the junction box and the LED LASER on the scanning head light up. Laser light is not yet emitted as the beam shutter is still closed.

NOTE !

Remember that the PSV reaches its optimal properties after a warm-up period of the laser of approx. 30 minutes.

4. Switch on all optional peripheral device.
5. Switch on the PC, start the PSV software and change to the Acquisition Mode as described in your software manual.

   On changing the Acquisition Mode, control of the PSV via the software is activated. Making changes on the settings of the controller are now only possible via the software.

6. Before now opening the beam shutter, remember the information on laser safety provided in SECTION 1.2.
7. Open the beam shutter on the front of the scanning head.

   The laser beam is now emitted from the scanning head.

Measuring

8. Data acquisition is now fully controlled by the software. Once the laser has warmed up you can setup the software, set the optics, define the scan points and make measurements as described in your software manual.

4.2 Selecting Suitable Settings

4.2.1 Measurement Range

When selecting the measurement range, first of all take the expected maximum values on the measurement for the velocity and vibration frequency or acceleration into account. The respective values are given in the specifications (refer to SECTION 7.2.4).

many applications are covered by the 10 $\frac{mm}{s}$/V measurement range of the decoder VD-03 or VD-04 respectively. It should therefore be selected for initial measurements with the PSV. A higher measurement range only has to be selected in the LED OVER on the front of the controller lights up permanently at scan points to high amplitude.

Generally it is advisable to use the lowest possible measurement range for minimizing the noise and maximizing the optical sensitivity.

If either the positive or the negative limit of a measurement range has been reached, the overrange is indicated in the software and the LED OVER in the field VELOCITY lights up on the front of the controller. As a general rule, you should then select the next highest measurement range. However please note that this LED is activated even by very brief overloading which can also be caused by noise spikes. In such cases you can continue to use the velocity measurement range as long as it is suitable for the amplitude of the wanted signal. Observing the signal in the time domain will provide clarification on this.

With extremely weak optical signal, permanently lighting up of the LED OVER can be caused by noise due to the system. If switching on the tracking filter (refer to SECTION 4.2.3) can not eliminate this problem, you should check whether

- the laser is focused optimally
- the surface can be treated for optimizing the reflectivity or
- the stand-off distance can be changed.

4.2.2 Description of the Decoders

In contrast to the OFV-5000 controller used as a single point measurement device, with the PSV properties of the decoder are limited by the data acquisition. In the following sections only the standard PSV configurations are described. If you are using other decoders in the controller, please see your OFV-5000 controller manual on this.

VD-03

With its frequency range between 0.5 Hz and 1.5 MHz and a maximum velocity of 10 m/s, the VD-03 has got the largest operating range and can be used universally.

VD-08

The digital velocity decoder VD-08 offers in addition to the broadband decoder VD-03 eight high-resolution measurement ranges for the frequency range of 0 Hz to 25 kHz. With its lower cutoff frequency of 0 Hz, the VD-08 is also suitable for acquiring uniform or intermitted movements, or extremely low-frequency vibrations respectively.

The decoder is optimized for the highest optical sensitivity. Therefore, it can detect signal from the surface with low backscattering. This applies especially for three lower measurement ranges.

In the case of measurement task with analysis of the vibration phase, attention should be paid to the signal delay (frequency-dependent phase shift). Due to the digital signal processing (DSP technology) the signal delay is longer than for analog decoders. The phase error caused by the time delay will be corrected automatically in the frequency spectra by the PSV software (not in the time domain).

VD-09

Out of all available velocity decoder, the digital decoder VD-09 has with its frequency range of 0 Hz to 2.5 MHz and a maximal velocity of 10 m/s the largest operating range and can be used universal. As its lower cutoff frequency is 0 Hz, the VD-09 is also suitable in all measurement ranges for acquiring uniform or intermittent movements or extremely low-frequency vibrations respectively.

VD-07

The digital velocity decoder VD-07 offers in addition to the broadband decoder VD-09 six high-resolution measurement ranges for the frequency range of 0 Hz to 350 kHz. With its lower cutoff frequency of 0 Hz, the VD-07 is also suitable for acquiring uniform or intermitted movements, or extremely low-frequency vibrations respectively.

The decoder is optimized for the highest optical sensitivity. Therefore, it can detect signal from the surface with low backscattering. This applies especially to the measurement range $1\,\frac{mm}{s}/V$.

In the case of measurement task with analysis of the vibration phase, attention should be paid to the signal delay (frequency-dependent phase shift). Due to the digital signal processing (DSP technology) the signal delay is longer than for analog decoders. The phase error caused by the time delay will be corrected automatically in the frequency spectra by the PSV software (not in the time domain).

VD-04

With its frequency range from 0.5 Hz to 250 kHz and a maximum velocity of 10 m/s, the velocity decoder VD-04 covers the whole operating range of the PSV-400-B and reaches excellent resolution values of the measurement range of 10 $\frac{mm}{s}$/V.

VD-05

The VD-05 is designed for high-frequency applications up to 10 MHz using the PSV-400-M2-20 and is installed optionally as an auxiliary decoder. Because of its slightly inferior properties due to the principle it works on, it should only be used when the frequency range of the main decoder is insufficient.

Output signal: The output signal of the VD-05 is available at the BNC jack OUTPUT in the field AUXILIARY on the front of the controller. The output voltage swing of the decoder is nominal ±5 V according to the full scale values ±0.5 m/s or ±2.5 m/s respectively of the two measurement ranges. However, there is a headroom of about 20% so that peak values up to 3 m/s can be acquired without distortions.

With signal frequencies in the megahertz range, the load connected to the signal output can have great influence on the frequency response and the signal shape. The signal output of the VD-05 is designed for connecting high-impedance inputs of oscilloscopes or other signal acquisition systems (mostly 1 MΩ || 47 pF) via a BNC cable with a maximum length of approx. 1.5 m. If you attach considerably longer cables, it is recommended to use a 50 Ω-termination at the input of the subsequent instrument. In this case, the scaling factors of the measurement ranges change to 200 $\frac{mm}{s}$/V or 1000 $\frac{mm}{s}$/V respectively, while the output swing decreases to ±3 V.

Measurement range: Two measurement ranges with scaling factors of 100 $\frac{mm}{s}$/V and 500 $\frac{mm}{s}$/V are available for adapting to the vibration amplitude. If either the positive or the negative boundary of a measurement range has been reached, the LED OVER in the field AUXILIARY lights up on the front panel of the controller. Due to the headroom of about 20% you can also make measurements as long as no clipping is observed in the output signal.

Filter: The filters installed in the controller (tracking filter, low pass filter, and high pass filter) do not have any effect on the signals of the VD-05.

Noise: Due to the wide frequency bandwidth of the VD-05 you can observe, even with good backscattering properties of the object, relatively high background noise in the time domain. This background noise limits the amplitude resolution for transient motions. It can only be reduced by using average procedures in the subsequent signal processing. With signal evaluation in the frequency range, spectral resolutions of some $\frac{\mu m}{s}/\sqrt{Hz}$ can be reached. For physical reasons, the noise power density increases with frequency on velocity decoding. For technical reasons, single noise peaks can occur at determined frequencies in the specified limits of the spurious free dynamic range.

Impulse acquisition: The velocity decoder VD-05 can also be used for acquiring pulse-shaped signals. As in all systems with limited bandwidth, typical waveform distortions are generated which should be taken into consideration when evaluating the measurement results. In particular, rise time limitations for signals with a short ramp response and amplitude decay for square wave signals due to the absent DC capability of the decoder can be expected. For signals with a steep rising edge, transient effects with overshooting of the amplitude up to 20% are also induced by technical reasons. As a rule of thumb, square wave signals should not exceed a repetition rate of about 2 MHz.

DD-300

The displacement decoder DD-300 can be installed instead of the velocity decoder VD-05. The displacement decoder DD-300 is designed especially for ultrasonic applications. Using this decoder you can measure vibrations and pulse-shaped motions in a frequency range of 30 kHz to 24 MHz with amplitudes up to 75 nm (peak to peak). Thus the DD-300 is particularly suitable for amplitude measurements on ultrasonic transducers, for acquiring ultrasonic pulses or acquiring transient motion in the area of microsystems technology.

Furthermore, a special technique which suppresses vibrations in the acoustic range allows you to make measurements in a normal technical environment. Thus the measurement object under investigation does not have to be vibration-isolated.

NOTE !

Background vibration that exceed a velocity amplitude of approx. 10 mm/s (peak) can result in interferences in the measurement signal.

To use the displacement decoder DD-300 for scanning, you need specific experience and therefore it is not designated for the PSV-400-M2-20 by default.

Output signal: The output signal of the DD-300 is available at the BNC jack OUTPUT in the field AUXILIARY on the front of the controller. The input impedance of the system connected has to be 50 Ω.

Measurement range: Selecting a suitable measurement range is not necessary for the DD-300, as this decoder has only one measurement range available (50 nm/V).

Low pass filter: The filtered output signal of the DD-300 is available at the BNC jack UNIVERSAL in the field AUXILIARY on the front of the controller. The bandwidth of this signal is limited to 2 MHz. Using the filtered signal is recommended during signal analysis in the time domain to suppress noise if the signal bandwidth allows this.

Tracking filter: The tracking filter has no influence on measurements with the DD-300.

Noise: The displacement resolution which can be obtained in the time domain depends directly on the RMS value of white noise. The noise voltage, however, is generally relative high caused by the broad bandwidth of the DD-300. Therefore accurate focusing of the laser in the scanning head is very important when measuring amplitudes in the nanometer range. We recommend observing the displacement signal on an oscilloscope while optimizing the focus to attain a noise level as low as possible. On highly reflecting surfaces the signal level display is not sufficient to find the optimal focus position.

Two noise peaks with an amplitude of some millivolts can be observed in the spectrum of the measurement signal in the frequency range from 8 MHz to 25 MHz when making measurements on reflective surfaces These noise peaks come from the high-frequency fluctuation of the laser power and can not be suppressed electronically. Their exact frequency depends on the scanning head but it is almost constant. It can thus be easily distinguished from the proper ultrasonic signal.

Please note that in a 20 MHz bandwidth the noise level is a few millivolts, even in optimal measurement conditions. As a result, when using an oscilloscope, it is not possible to detect amplitudes below a threshold of approx. 0.2 nm.

Otherwise, with good optical signal quality and a resolution bandwidth of just 10 kHz, the noise level will not exceed 0.2 mV (RMS), which is equivalent to an amplitude of 0.01 nm. It is thus evident that in order to detect very small amplitudes it is always useful to limit the bandwidth, e.g. by using narrow-band filters, a spectrum analyzer or a lock-in amplifier. Using a spectrum analyzer, amplitudes of less than 1 pm can be measured in optimum conditions.

4.2.3 Tracking Filter

The tracking filter can be used to improve the signal-to-noise ratio of the input signal of the scanning head. This filter bridges brief dropouts, which always occur due to the speckle nature of the light scattered back from the object.

When using the digital velocity decoder VD-07/VD-08, the tracking filter does not have any effect.

To reduce noise, the tracking filter works best with a high time constant (corresponds to the tracking filter mode Slow in the software and on the display of the controller). With a high time constant however, it may not be possible to track highly dynamic signals. In such cases, the tracking filter either needs to be switched to the mode fast (Fast) or needs to be switched off (Off). You will need to ascertain the most favorable setting for the tracking filter from case to case or estimate it based on the range diagram in FIGURE 4.1. The range diagram shows the performance data with the dynamic limits for both settings of the tracking filter, plotted over the frequency.

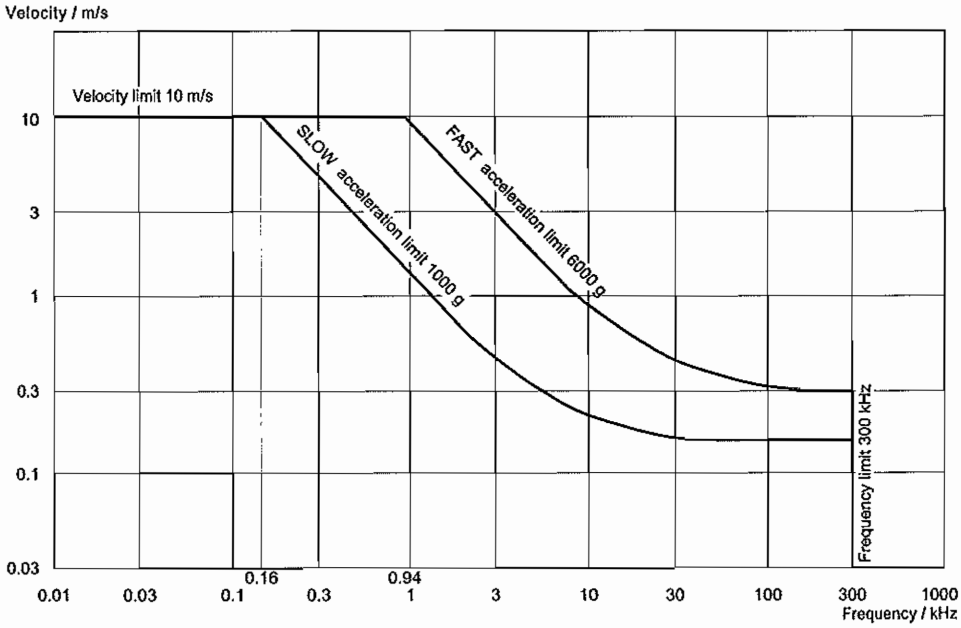

Figure 4.1: Schematic range diagram of the tracking filter

It is characteristic for the maximum velocity to decrease with increasing frequency. The maximum velocity of 10 m/s can only be processed up to a cutoff frequency of 160 Hz or 940 Hz respectively. Above that, the velocity limit transforms into an acceleration limit, i.e. the cutoff velocity decreases inversely proportionally to the frequency. For velocities below 150 mm/s or 300 mm/s, acceleration no longer have to be taken into account.

For the setting of the tracking filter, the range diagram in FIGURE 4.1 can be summarized with the following rules of thumb:

- Use the tracking filter in connection with analog velocity decoders to improve the signal noise if the optical signal is weak. If you have a good optical signal, it is not possible for the tracking filter to improve the signal-to-noise ratio for physical reasons. It should be switched off if detrimental effects can be identified.

- Select the mode slow (Slow) or fast (Fast) depending in the signal dynamics. Below a certain velocity, no dynamic limits need to be observed. For this reason, in the lower measurement ranges to $10\frac{mm}{s}/V$ as a general rule you can set the tracking filter mode slow (Slow).
- For average velocities and frequencies, the acceleration limits of the tracking filter have to be taken into account. The optimum setting has to be found using the range diagram. If the velocity or acceleration limit of the tracking filter is exceeded, then the internal phase-locked loop loses lock. The signal is then distorted roughly. In FIGURE 4.2 you can see an example of an oscillogram showing a distorted signal. Signal A shows a sinusoidal velocity signal with the tracking filter switched off. Signal B shows the same signal with the tracking filter switched on in mode slow (Slow). Here the tracking filter is at the limit of losing lock and the signal is partially being distorted.

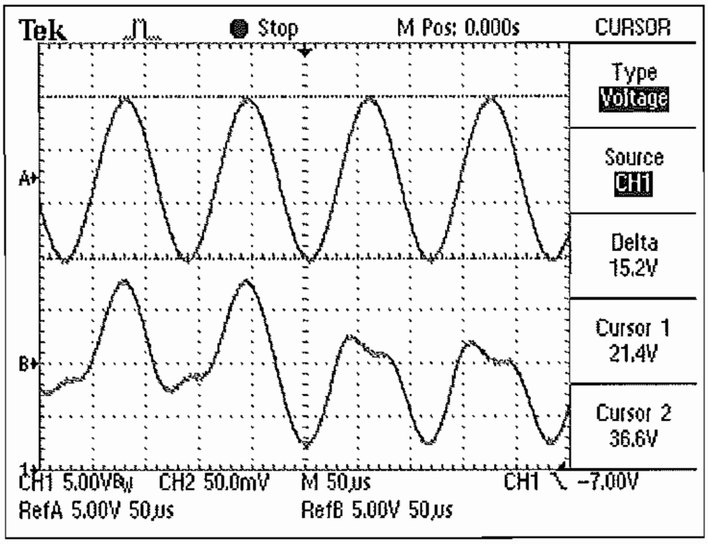

Figure 4.2: True velocity signal (A) and signal when the tracking filter loses lock (B)

- For particularly precise measurements, the tracking filter should be switched off because it can cause amplitude errors of up to 0.5dB. For measured frequencies which are above 300kHz, as a general rule the tracking filter should always be switched off (Off).

4.2.4 Low Pass Filter

The controller is equipped with adjustable, analog low pass filters so that the measurement bandwidth of velocity acquisition can be adapted to suit the respective application. When presenting the measurement signals in the time domain, the signal-to-noise ratio can be improved by limiting the bandwidth to the necessary measure. For analysis in the frequency domain using PSV software, low pass filters only play a secondary role. Here you can reduce overloading the data acquisition system which has been caused by noise effects.

You can select analog low pass filters with the cutoff frequencies 5kHz, 20kHz, 100kHz or 1.5MHz for the output signal of each selected velocity decoder. Using the setting Off the filter will be switched off, so that the frequency bandwidth is only determined by the velocity decoder.

Apart from that, the digital decoders VD-07 and VD-09 offer you the possibility of limiting the bandwidth with a digital low pass filter. Some measurement ranges are available twice (refer to SECTION 7.2.4): Once with the maximal frequency and once with the reduced frequency (labeling "LP"). As digital filters have significantly better properties than analog filters, a bandwidth limitation should always be carried out with this digital low pass filter first when using this digital decoder. For further bandwidth limitations you can then use the analog low pass filters in addition.

For precise measurements, you must pay attention to the frequency response of the analog low pass filter. The corresponding diagrams for amplitude frequency response, amplitude error and phase frequency response of the low pass filter used can be found in SECTION C.1. The frequency response of the digital low pass filter in the VD-07 and VD-09 can be ignored as digital filters have got almost ideal properties. If you do not wish any additional bandwidth limitation, set the low pass filter in connection with the broadband decoder VD-09 in position Off, with all other decoders in position 1.5MHz. Under these condition the specifications for amplitude and phase frequency response of the respective decoder are valid and the automatic phase correction attains their complete accuracy.

NOTE !

The PSV software corrects the time delay of the velocity decoder, but not that of the analog low pass filter. **Therefore, switch off the high pass filter when scanning,** if you use the broadband decoder VD-09. In connection with all other decoders please choose the setting 1.5MHz.

The analog low pass filters have got third order Bessel characteristics. The phase linearity from the frequency zero to the cutoff frequency is characteristic for this filter type, i.e. the phase shift increases in proportion to the frequency. However these filters cause amplitude errors in the pass band which can be roughly estimated:

- Up to 40% of the cutoff frequency, the amplitude error is less than −5%.
- In the range up to 70% of the cutoff frequency, the amplitude error increases to approx. −15%.
- The upper 30% of the pass band should only be used for orientation purposes. At the cutoff frequency set for the filter, the amplitude error is −3dB (approx. −30%).

The phase shift increases in proportion to the frequency from close to zero degrees at a few hertz to approx. −100 degrees at the cutoff frequency (refer to FIGURE C.3). Due to the linear phase frequency response, the filter transmits pulses optimally, as all frequencies in a complex wave are subjected to the same time delay. The shape of the pulse is thus not distorted, but merely subjected to a time delay.

An additional time delay is caused by the velocity decoder. This depends on the velocity decoder used and also on the velocity measurement range and is several micro seconds long. The resulting phase shift $\Delta\Phi$ can be estimated using the following simple equation:

$$\Delta\Phi = 100^\circ \cdot \frac{f}{f_c} + p_D \cdot f \qquad \text{Equation 4.1}$$

f ... frequency in kHz

f_c ... cutoff frequency of the low pass filter in kHz

p_D ... frequency-dependent phase shift of the decoder in °/kHz

4.2.5 High Pass Filter

The high pass filter is the type 4th order Butterworth. Here it can be said:

- At 150 Hz (1.5 times cutoff frequency f_c) the amplitude error is approx. −5%.
- The high pass filter generates a frequency-dependent phase shift (refer to SECTION C.2). Switch off the high pass filter if this phase shift is not desired.

NOTE !

The high pass filter is **only** suitable for single point measurements. During scanning, the high pass filter causes signal distortion due to the longer settling time after moving the mirrors. **Therefore, switch off the high pass filter when scanning!**

Apart from that you should note that when the high pass filter is switched on, it may no longer be possible to identify in the measurement signal when the decoder has been overloaded as the corresponding frequency is filtered out. Measurement tasks in which a small measurement signal is superimposed by a low-frequency machine vibration with a large amplitude are particularly critical. The measurement signal is then significantly distorted and the LED OVER in the field VELOCITY on the front of the controller is continuously lit up, even though overloading is not apparent in the measurement signal. In such cases, you should proceed as follows:

1. First of all, switch the high pass filter off and set the smallest measurement range which is not overloaded for the decoder you have selected.

2. Then switch on the high pass filter for the actual measurement.

Please note that the LED OVER can also be lit up due to brief noise spikes resulting from inferior optical signal quality. This effect does not yet lead to signal distortions by overloading the decoder.

The complete amplitude frequency response of a 4th order Butterworth high pass filter as well as the corresponding amplitude error and phase frequency response are shown in SECTION C.2.

4.3 Setting Optimal Stand-off Distances

4.3.1 Coherency between Stand-off Distance and Visibility Maximum

Visibility maxima

The light source of the PSV is a helium neon laser. These are multi-mode lasers in which, depending on the laser cavity length, one or a maximum of two modes can exist. The laser cavity length can vary caused by small changes in temperature. Thus the laser changes between the one-mode state and the two-mode state. If two modes exist, interference effects cause the intensity of the resulting optical signals varying periodically with the stand-off distance.

The diagram in FIGURE 4.3 shows the signal level depending on the stand-off distance. In this special case of having two modes with equal magnitude (black line), you have the strongest loss of signal level if the object is located inside a visibility minimum. But generally there are two modes of different magnitudes. In this case the signal level is hardly fluctuating (gray line). If only one mode exists, the signal level is always maximum, independent from the stand-off distance (dashed gray line).

The stand-off distance at which the signal level is maximal are called visibility maxima. The visibility maxima recur every 204 mm (±1 mm) corresponding to the laser cavity length.

Generally it is not necessary to search for the visibility maximum as the PSV is sensitive enough to make measurements even close to the minimum. A visibility minimum is indicated during the warm-up phase by periodic fluctuation of the optical signal level. If you need an optimal resolution and sensitivity for small objects, you should select a stand-off distance close to the visibility maximum for each scanning head. As a rule of thumb, that the resolution and the sensitivity just degrades insignificantly in the range of ±90 mm around the visibility maximum.

Stand-off distance

The stand-off distance is measured from the front panel of the scanning head (refer to FIGURE 4.3).

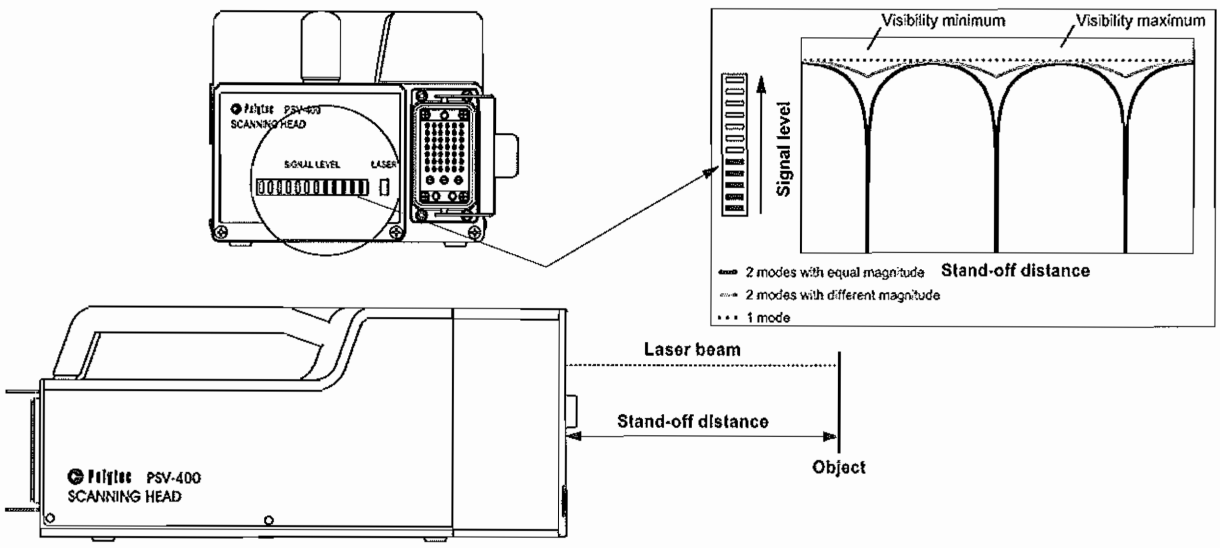

Figure 4.3: Measuring the stand-off distance

4.3.2 Stand-off Distance for the Scanning Head

The optimal stand-off distance for the scanning heads are shown in FIGURE 4.4.

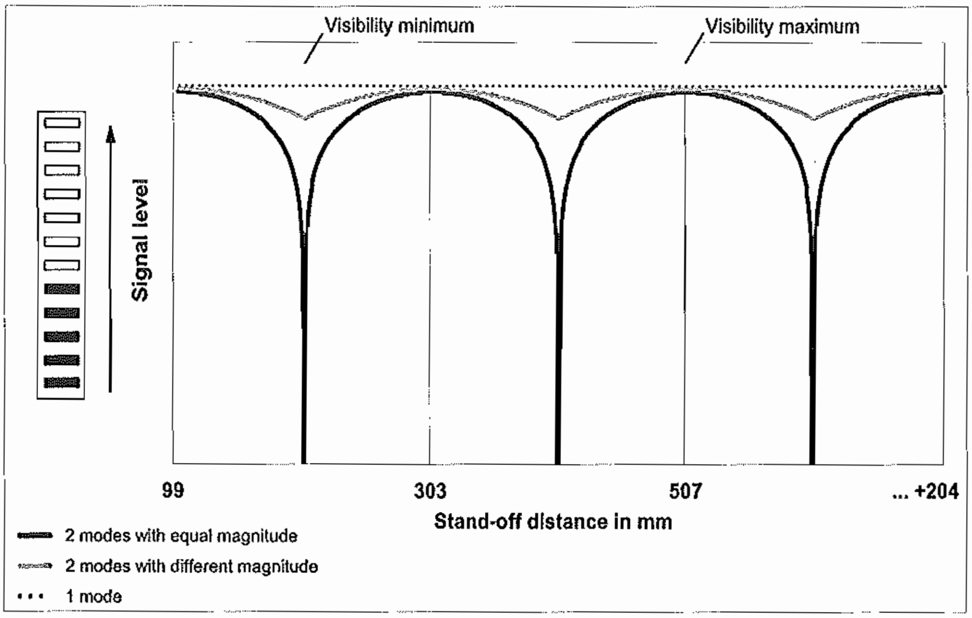

Figure 4.4: Optimal stand-off distance for the scanning heads

The optimal stand-off distance are:

$$\text{Optimal stand-off distance} = 99\text{mm} + (n \cdot l)\text{mm}$$

$n = 0, 1, 2, \ldots$ $\qquad$ $l = 204\,\text{mm} \pm 1\,\text{mm}$

i.e. for l = 204 mm the optimal stand-off distances are:
99 mm, 303 mm, 507 mm, 711 mm, 915 mm etc.

Front lens models

Depending on the front lens model which is installed in your scanning head, the following meaningful stand-off distances results (refer also to SECTION 7.6.2).

Front lens model	Stand-off distances
Long Range (LR)[1]	507 mm, 711 mm, 915 mm, 1119 mm etc.
Mid Range (MR)	303 mm, 507 mm, 711 mm, 915 mm etc.

[1] installed as standard

5 Operating the PSV

5.1 Switching On and Off

Controller

The controller is switched on by turning the key switch on the front panel to position I. The LED POWER above the key switch lights up and shows that the controller is ready to operate.

Is the PSV cabled correctly as described in SECTION 3.4.2, the LED POWER on the front of the junction box also lights up and shows that the junction box is ready to operate. Also the LED LASER on the scanning head lights up and shows that the scanning head is ready to operate and the laser is active, even if the beam shutter is closed (refer to SECTION 5.2 and SECTION 5.3).

PC

To switch on the PC, first set the mains switch on the back to position I. Then open the front flap using the key and press the black POWER key.

Software

If the PSV is cabled completely and all instruments are switched on, start the software. See your software manual on this.

5.2 Blocking the Laser Beam

The scanning head is equipped with a beam shutter. This can be used to block the laser beam without switching off the laser. Thus keeping the system in thermal equilibrium.

The rotary knob for the beam shutter is on the front of the scanning head and is labeled EMISSION ON/OFF. To block the laser beam, turn the knob counterclockwise until the mark points at OFF.

WARNING !

Danger from laser light ! - Only open the beam shutter when you are making measurements!

WARNING !

Danger from laser light ! - To position the scanning head, always close the beam shutter. Only when the scanning head is roughly in place and has bee fixed in a stable position, open the beam shutter for precise adjustment!

5.3 Indicating Laser Activity

On the back of the scanning head the LED LASER indicates the laser activity. The LED is lit while the laser is active (key switch on the front of the controller in position I). The LED is lit regardless of whether the beam shutter is open or closed.

5.4 Setting up the Scanning Head

Fluid stage

If your PSV is equipped with a tripod and fluid stage, you can manually set up the scanning head using the three hand-grips as described in the assembly instruction providing by the manufacturer MANFROTTO.

Pan-tilt stage (optional)

If your PSV is equipped with a heavy duty tripod and a motorized pan-tilt stage, it is easier to set up the scanning head. You can control the pan-tilt stage via the software (refer to the software manual).

Using the icons in the scanning head control in the software, the scanning head can be panned to the left or right by ±90° and can be tilted upward or downward by ±84°.

> **CAUTION !**
>
> ⚠ **Danger from overload!** - Avoid any additional weight on the pan-tilt stage by placing the heavy objects on top of the scanning head as this can put strain on the pan-tilt stage!

Stand-off distance

Please pay also attention to the information on optimal stand-off distance for the scanning head provided in SECTION 4.3.

5.5 Positioning the Laser Beam

There are different ways to position the laser beam:

- In the software (refer to the software manual)
- With the hand set PSV-Z-051

Software

When the PSV is controlled via the software, you can use the icons Position in the software to position the laser beam. See your software manual on this.

Hand set PSV-Z-051

The hand set PSV-Z-051 is connected to the circular jack REMOTE CONTROL on the front of the scanning head. You can position the laser beam using the emphasized part of the hand set shown in SECTION 5.1.

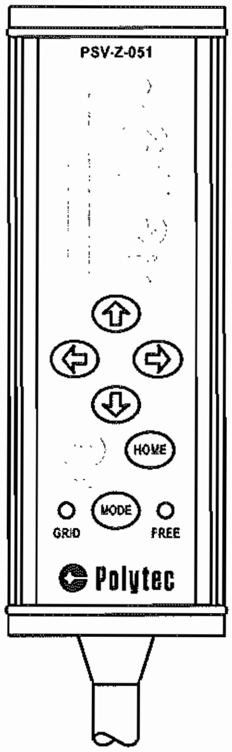

Figure 5.1: Positioning the laser beam using the hand set PSV-Z-051

For positioning the laser beam, proceed as follows:

1. Switch on the PSV (at least the PC) and start the PSV software.
2. Change to the Acquisition Mode as described in your software manual.
3. Press the MODE key on the hand set to select the kind of movement.

   The laser beam can be positioned in the GRID mode or in the FREE mode

GRID mode (LED GRID is lit up)

You move the laser beam on already defined alignment points or scan points using the arrow key. The order in which the software approaches the points is determined by an internal algorithm. Using the key →, you move the laser beam forwards along the points and backwards with the key ←.

FREE mode (LED FREE is lit up)

You move the laser beam freely using the four arrow keys. To do so, press the arrow key for the direction you require. If you press the HOME key, then the laser beam is positioned so that it is emitted from the scanning head perpendicular to the front panel (position (0;0), is indicated in the software).

5.6 Focusing the Laser Beam

To get the highest possible quality of the measurement signal, the laser beam has to be optimally focused. The laser beam is optimally focused when the diameter of the laser beam target area on the object is as small as possible. Due to blooming effects in the focus point, it is often difficult to ascertain when the smallest diameter has been reached. For this reason you can alternatively observe the signal level display in the software, on the scanning head or on the controller. The more signal level is shown, the better the focus of the laser beam.

As the actual aim of focusing is to minimize the undesired noise signals, you can also orientate yourself directly towards the output signal from the controller when focusing. Observe the output signal in the software while focusing the laser beam on the unmoved object. The better the focus of the laser beam, the smaller the amplitude of the noise.

There are different ways to focus the laser beam:

- Remote or automatic focusing via the software (refer to software manual)
- Remote or automatic focusing using the hand set PSV-Z-051 (refer to SECTION 5.6.2
- Remote or automatic focusing via the display of the controller (refer to SECTION 5.6.3 Remote Focus or Auto Focus, only without using the software)

5.6.1 Focusing the Laser Beam via the Software

When the PSV is controlled via the software, you can remotely and automatically focus the laser beam using the icons in the software. See your software manual on this.

5.6.2 Focusing the Laser Beam using the Hand Set PSV-Z-051

Focus manually

The hand set PSV-Z-051 is connected to the circular jack REMOTE CONTROL on the front of the scanning head. You can focus remotely (manually) the laser beam using the emphasized part of the hand set shown in FIGURE 5.2.

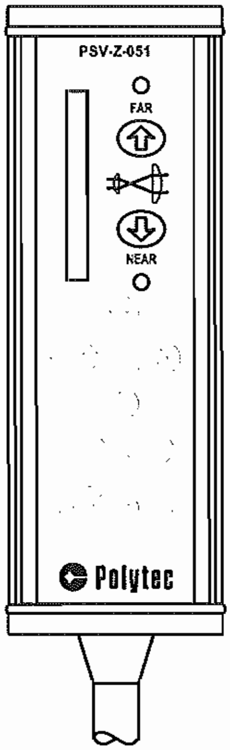

Figure 5.2: Focusing the laser beam manually using the hand set PSV-Z-051

For manual focusing the laser beam, proceed as follows:

1. Switch on the PSV (at least the PC) and start the PSV software.
2. Change to the Acquisition Mode as described in your software manual.
3. Focus the laser beam using the two arrow keys FAR and NEAR as follows:

   - Focusing on infinity: Key ↑ FAR
   - Focusing on close-up: Key ↓ NEAR

If you press the keys for more the approximately one second, the motor switches over to fast mode. For fine positioning, the keys can be repeatedly pressed briefly. At the end of the adjustment range, the motor stops automatically and the respective LED FAR or NEAR respectively light up.

Beside the keys for focusing, there is a signal level display which helps you to optimize the focus. The signal shown is identical to that in the software and on the scanning head.

Focus automatically

The hand set PSV-Z-051 is connected to the circular jack REMOTE CONTROL on the front of the scanning head. You can focus automatically the laser beam using the emphasized part of the hand set shown in FIGURE 5.3.

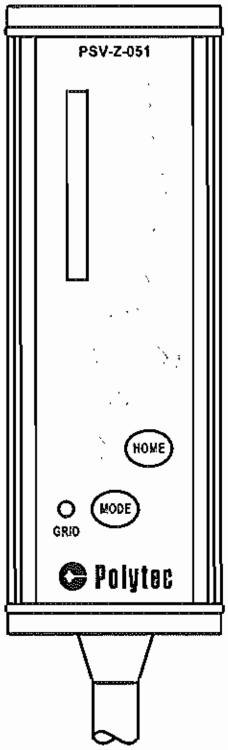

Figure 5.3: Automatically focusing the laser beam using the hand set PSV-Z-051

For automatically focusing the laser beam, proceed as follows:

1. Switch on the PSV (at least the PC) and start the PSV software.
2. Change to the Acquisition Mode as described in your software manual.
3. Change to the GRID mode by pressing the MODE key on the hand set (LED GRID is lit up).
4. Press the HOME key.

   Now the laser beam will be focused automatically.

5.6.3 Focusing the Laser Beam using the Controller

When the controller is operated without the software, you can focus the laser beam via the menu Auto & Remote Focus (refer to SECTION 5.15.3).

5.7 Using the Signal Level Display

The signal level display helps you to optimize the focus of the laser beam. The signal levels shown as a bar display:

- On the back of the scanning head
- In the software (refer to your software manual)
- On the hand set PSV-Z-051 (refer to SECTION 5.6.2)
- On the display of the controller (only without using the software)

5.8 Changing Settings

Software

When the PSV is controlled via the software, all settings are adjusted via the software. See your software manual on this. In this case the function keys on the front of the controller do not have a function.

You will find information on setting the measurement range and the filters in SECTION 4.2.

Controller

When the controller is operated without the software, you can set the measurement range and the filter via the menus on its display using the function keys (refer to SECTION 5.15.4).

5.9 Indicating Overrange

Software

Overranging the measurement range is indicated in the software. See your software manual on this.

Controller

If the LED OVER in the field VELOCITY on the front of the controller is lit up continuously, it means that the measurement range set is exceeded. In this case the next highest measurement range must be selected. You will find further information on setting the measurement range in SECTION 4.2.1.

5.10 Defining Alignment Points

There are different ways to define, check and delete alignment points for the 2D alignment and the 3D alignment:

- In the software (refer to the software manual)
- With the hand set PSV-Z-051

Software

When the PSV is controlled via the software, you can use the software to define and delete alignment points. See your software manual on this.

Hand set PSV-Z-051

The hand set PSV-Z-051 is connected to the circular jack REMOTE CONTROL on the front of the scanning head. You can define and delete individual alignment points using the emphasized part of the hand set shown in FIGURE 5.4. To do so, proceed as follows:

1. Switch on the PSV (at least the PC) and start the PSV software.

2. 2D alignment: Change to the Acquisition Mode and select Setup > 2D Alignment as described in your software manual.

   3D alignment: Change to the Acquisition Mode, then select Setup > Align 3D Coordinates *and select* Set new alignment point at laser spot *as well as* unit *(m or mm) as described in your software manual.*

3. to define alignment points, change to the FREE mode by pressing the MODE key on the hand set (LED FREE is lit up).

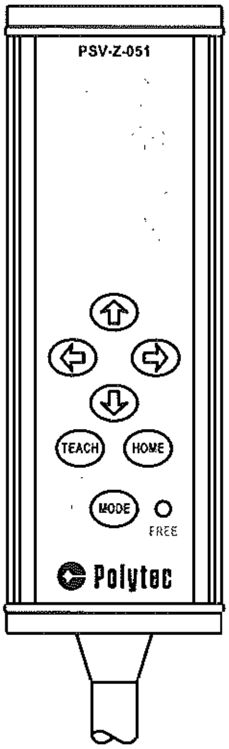

Figure 5.4: Defining alignment points using the hand set PSV-Z-051

4. Using the four arrow keys, move the laser beam to the desired position.

> **NOTE !**
>
> The more precisely the alignment is carried out, the better the measurement result will be. So please take your time setting the alignment points!

5. Press the TEACH key and the alignment point is defined.

   The newly defined alignment point is shown in the software.

> **NOTE !**
>
> Pay attention that there are no persons or moving objects within the field of vision of the video camera and in the beam path of the laser as otherwise it is not possible to set an alignment point.

> **NOTE !**
>
> Pay attention that there are no multiple reflections on the object under investigation caused by reflections of the laser beam as otherwise it is not possible to set the alignment point on the desired position.

6. Repeat steps 4 and 5 until all desired alignment points are defined.

> **NOTE !**
>
> Pay attention to the number of alignment points on the object! In principle for an alignment, it is enough to define four alignment points. For the best possible result however, you should align at least five points.

For detailed information on how to carry out the 3D alignment, refer to your software manual.

5.11 Checking Alignment Points using the Hand Set PSV-Z-051

5.11.1 2D Alignment

If you have calculated 2D alignment, you can select and check the existing alignment points using the hand set as described in the following:

1. Change to the GRID mode by pressing the MODE key on the hand set (LED GRID is lit up).

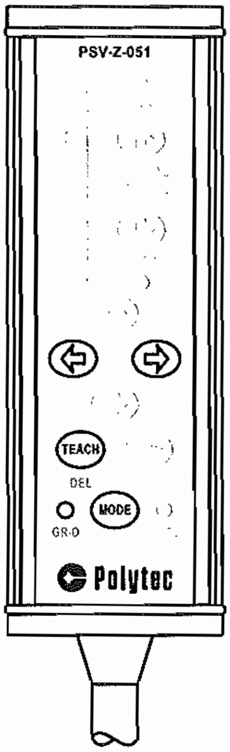

Figure 5.5: Checking alignment points using the hand set PSV-Z-051

2. Use the arrow keys ← (former) and → (next) to move the laser beam to the desired alignment point.

   If you want to delete an alignment point, proceed as described in SECTION 5.12.

5.11.2 3D Alignment

If you have calculated 3D alignment, you can select and check the existing alignment points using the hand set as described in the following:

1. In the software in the dialog 3D Alignment, tick the box Select and check existing point.
2. Change the GRID mode by pressing the MODE key on the hand set (LED GRID is lit up, refer to FIGURE 5.5).
3. Use the arrow keys ← (former) and → (next) to move the laser beam to the desired alignment point.

   If you want to delete an alignment point, proceed as described in SECTION 5.12.

NOTE !

Once you delete an alignment point, the calculated 3D alignment becomes invalid. Then you can not toggle the alignment points any more using the hand set!

5.12 Deleting Alignment Points using the Hand Set PSV-Z-051

5.12.1 2D Alignment

To delete defined alignment points in the 2D alignment using the hand set, you have two possibilities:

- Manually position the laser beam on the alignment points and delete the alignment points.
- Toggle the alignment points with the laser beam and delete the alignment points.

Manually positioning

To manually position the laser beam on an alignment point and to delete the alignment point, you proceed as follows:

1. Change the FREE mode by pressing the MODE key on the hand set (LED FREE is lit up, refer to FIGURE 5.4).
2. Using the four arrow keys, move the laser beam to the alignment point you want to delete.
3. Change to the GRID mode by pressing the MODE key on the hand set (LED GRID is lit up).

   The TEACH key now functions as the DEL key (for deleting).
4. Press the DEL key and the selected alignment point is deleted.
5. Repeat steps 1 to 4 until all desired alignment points are deleted.

Toggle

To toggle the alignment points with the laser beam and to delta them, remove as follows:

1. Change the GRID mode by pressing the MODE key on the hand set (LED GRID is lit up, refer to FIGURE 5.5).
2. Use the arrow keys ← (former) and → (next) to move the laser beam to the desired alignment point.
3. If you want to delete this alignment point, press the DEL key on the hand set.
4. Repeat steps 2 and 3 until all desired alignment points are deleted.

5.12.2 3D Alignment

To delete defined alignment points in the 3D alignment using the hand set, you have got only the possibility to manually position the laser beam on the alignment point and to delete the alignment point. To do so, proceed as follows:

1. Change the FREE mode by pressing the MODE key on the hand set (LED FREE is lit up, refer to FIGURE 5.4).
2. Using the four arrow keys, move the laser beam to the alignment point you want to delete.
3. Change to the GRID mode by pressing the MODE key on the hand set (LED GRID is lit up).

   The TEACH key now functions as the DEL key (for deleting).
4. Press the DEL key and the selected alignment point is deleted.
5. Repeat steps 1 to 4 until all desired alignment points are deleted.

NOTE !

Toggling the alignment points is **only** available for a calculated 3D alignment. Once you delete an alignment point, the calculated 3D alignment becomes invalid. Then you can not toggle the alignment points any more using the hand set!

5.13 Defining and Deleting Scan Points (APS)

There are different ways to define and delete scan points:

- In the software (refer to the software manual)
- Using the hand set PSV-Z-051

> **NOTE !**
>
> defining and deleting individual scan points is only possible if you have the software option APS Professional PSV-S-APS!

Software

When the PSV is controlled via the software, you can use the software to define and delete single scan points. See your software manual on this.

Hand set PSV-Z-051

The hand set PSV-Z-051 is connected to the circular jack REMOTE CONTROL on the front of the scanning head. You can define and delete single scan points using the emphasized part of the hand set shown in FIGURE 5.6. To do so, proceed as follows:

1. Switch on the PSV (at least the PC) and start the PSV software.
2. Change to the Acquisition Mode, then select Setup > Define Scan Points and here select the Point Mode as described in your software manual.

> **NOTE !**
>
> Make sure that you have carried out a valid 2D and 3D alignment before!

3. To **define scan points,** change to the FREE mode by pressing the MODE key on the hand set (LED FREE is lit up).

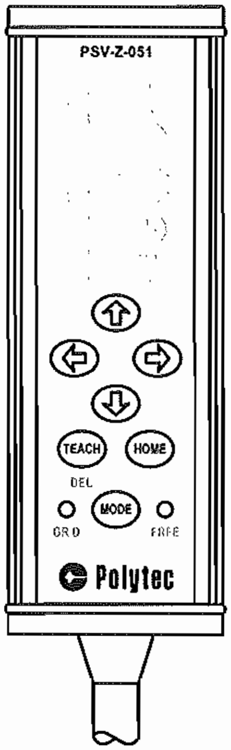

Figure 5.6: Defining and deleting scan points using the hand set PSV-Z-051

4. Using the four arrow keys, move the laser beam to the desired position.
5. Press the TEACH key and the scan point is defined.

   The newly defined scan point is shown in the software.

NOTE !

Pay attention that there are no persons or moving objects within the field of vision of the scanning head's video camera as otherwise it is not possible to set a scan point.

NOTE !

Pay attention that there are no multiple reflections on the object under investigation caused by reflections of the laser beam as otherwise it is not possible to set the scan point on the desired position.

6. Repeat steps 4 and 5 until all desired scan points are defined.

NOTE !

To get a 3D view of the measurement data, you have to define connections in the software. See your software manual on this!

7. To **delete defined scan points**, change to the GRID mode by pressing the MODE key on the hand set (LED GRID is lit up).

   The TEACH key now functions as the DEL key (for deleting).

8. Press the DEL key and the selected scan point is deleted.

9. For deleting further scan points, select them using the arrow keys ← or → and delete them by pressing the DEL key.

5.14 Overview above the Functions of the Hand Set PSV-Z-051

The following table contains an overview of the individual functions which you can carry out using the hand set PSV-Z-051. You can carry out the individual functions repeatedly.

Mode (LED)	Key	Video window	Define scan points	2D alignment	3D alignment
FREE	↑	Move the laser beam up			
FREE	↓	Move the laser beam down			
FREE	←	Move the laser beam to the left			
FREE	→	Move the laser beam down to the right			
FREE	HOME	Center the laser beam (position 0°;0° within the software)			
FREE	TEACH	Without function	Set scan point	Set alignment point	
GRID	↑	Without function			
GRID	↓	Without function			
GRID	←	Toggle last scan point		Toggle last alignment point[1]	
GRID	→	Toggle next scan point		Toggle next alignment point[1]	
GRID	HOME	Automatically focus the laser beam			
GRID	TEACH (DEL)	Without function	Delete selected scan point	Delete selected alignment point	
	↑ (FAR)	Manually focus the laser beam of the scanning head			
	↓ (NEAR)	(An LED at the respective key lights up, if the end of the focusing range is reached.)			

[1] In 3D alignment: At first you need a calculated 3D alignment and then you have to select Select and check existing point in the dialog 3D Alignment in the software.

5.15 Operating the Controller without the Software

5.15.1 Operating Concept

The controller is operated via a menu shown on the display. The contents of this menu control automatically adapt to the existing hardware configuration of the controller. You select the menus and the individual settings using the function keys next to the display. The function of these keys changes and depends on the page currently being shown on the display. The respective current function of the key can be seen by the icon displayed directly next to the function key.

The adjustable parameters of the controller have been assigned to the following three menus:

- The menu Settings contains all parameters which can be set individually for a particular measurement.
- The menu Sensor contains all parameters which concern the scanning head.
- The menu Setup contains all basic parameters for the controller which are not assigned to a particular measurement.

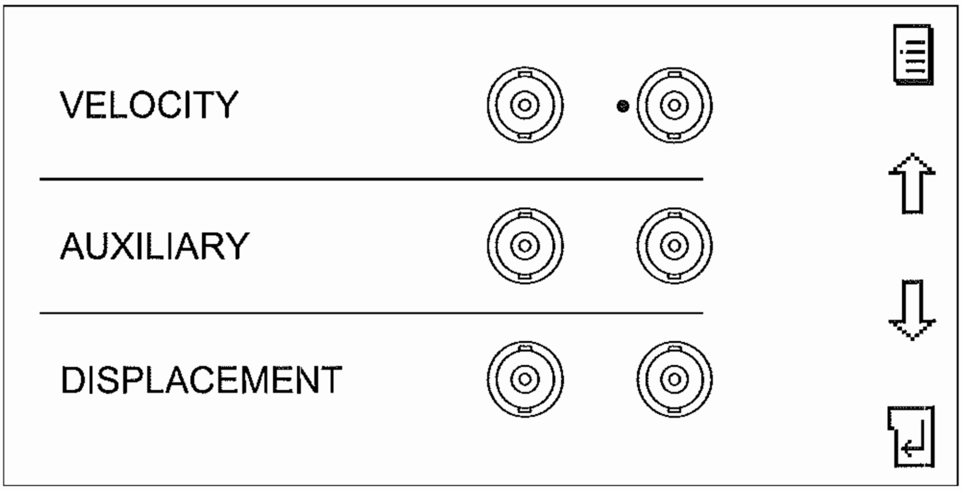

Figure 5.7: Page Settings on the display of the controller

Three settings can be saved in a flash memory. Before switching off the controller you can then select whether one of these three saved settings is loaded automatically next time you switch on, or alternatively, the settings selected last are loaded (refer also to SECTION 5.15.5).

You will be informed of malfunction of the system, operating errors (such as the scanning head accidentally not being connected) and advice by various messages on the display (refer also to SECTION 5.15.6 and SECTION 6.4).

5.15.2 Moving within the Menus

You can call up the main menu of the controller at any time by pressing the key ☰. From these menus you can access all sub-menus and parameters of the controller. You move through the menus using the keys ⇩⇧. The respective menu item you have selected is then marked on the left by a selection point. Once you have selected the required menu item, confirm your selection by pressing the key ↵. The page for the menu you have selected is displayed.

The main menu of the controller is made up of the following four menu items:

Back - If you select the menu item Back, you will always go back up a menu level. If selecting this menu item has no effect on the display, then you are already at the highest menu level (Settings, Sensor or Setup).

Settings - The menu Settings contains all settings for the controller which are relevant for a measurement (decoder selection, measurement ranges, filter settings etc.).

Sensor - The menu Sensor contains all settings which concern the scanning head (e.g. the focusing), if the scanning head connected can be controlled remotely from the controller.

Setup - The menu Setup contains the configuration of the controller and other settings which are not directly associated with a particular measurement (e.g. saving the settings, interface configuration).

In the sub-menus you also move around using the keys ⇩⇧ and confirm your selection by pressing the key ↵. For orientation purposes, the top line of each page shows you the path of exactly which point in the menu structure you are currently at (e.g. Settings [Velocity OUTPUT] is the page with the settings for the analog velocity signal in the menu Settings).

5.15.3 Focusing the Laser Beam

There are different ways to focus the laser beam via the display of the controller:

- Focus remotely (Remote Focus)
- Focus automatically (Auto Focus)

Apart from that, you can save a focus position set on the controller in the flash memory and load it again.

Remote Focus

Using the function Remote Focus you can focus the scanning head remotely via the display on the controller. To do so, proceed as follows:

1. Open the main menu by pressing .
2. Use ⇩⇧ to select the menu Sensor and confirm with .
   The page Sensor *is displayed.*
3. On this page use ⇩⇧ to select the menu item Auto & Remote Focus and confirm with .
   The page Sensor [Auto&Remote Focus] *is displayed.*
4. On this page use ⇩⇧ to select the parameter Remote Focus and activate it by pressing .
5. Now change the position of the optics by using ⬆⬇. If you just press the keys briefly, the position of the optics is changed step by step. If you hold the keys pressed, the optics quickly moves longer distances. The internal position of the optics is always shown in the graphics in the upper part of the display, e.g. <-()-> :1234, while in the field Remote Focus the direction is displayed. The following readouts are possible here:
   If near *is displayed, the focus point is moving towards the scanning head, with* far *the focus point is moving away from the scanning head.*

<-()->	limit [0]	1...3299 (step by step)	move	limit [3300]
Remote Focus:	<near>	near< or far>	near<< or far>>	<far>
Meaning:	Start point reached	Key briefly pressed	Key permanently pressed	End point reached

6. When focusing, orientate yourself towards the signal level or the noise amplitude as also described in SECTION 4.2.
7. As soon as you have optimally focused the laser beam, confirm the position with .

Auto Focus

The function Auto Focus available for the scanning head traverses the adjustment range of the optics and ascertains the position at which the intensity of the reflected light received reaches its maximum.

> **NOTE !**
>
> The function Auto Focus only provides a meaningful result if the laser beam is pointed at an unmoving object while focusing!

To start the Auto Focus, proceed as follows:

1. Open the main menu by pressing ☰.
2. Use ⇩⇧ to select the menu Sensor and confirm with ↵.

   The page Sensor *is displayed.*
3. On this page use ⇩⇧ to select the menu item Auto & Remote Focus and confirm with ↵.

   The page Sensor [Auto&Remote Focus] *is displayed.*
4. On this page use ⇩⇧ to select the parameter Start Auto Focus and activate it by pressing ↵.

   The controller starts focusing the laser beam automatically. This changes the diameter of the target area of the laser beam on the object which makes the signal level display on the scanning head or respectively the display of the controller fluctuate, depending on this diameter.
5. Automatic focusing is completed once the focus range of the scanning head has been traversed twice. The internal position of the optics is shown in the graphics in the upper part of the display, e.g. AF: 1234.

   The laser beam is now focused and ready to make measurements. If the laser beam should not be focused or there is no numerical value in the field AF:, then Auto Focus was not successful (refer to subsequent section).

Problems can occur with Auto Focus particularly if

- the object under investigation has got an optically irregular surface
- or a very small object is to be measured in front of a reflective background.

In such cases, the signal level with a badly focused laser beam may be higher than with an optimally focused laser beam. The function Auto Focus then identifies out of focus as the supposedly optimal setting.

You may be able to solve the problem by:

- increasing the reflectivity of the surface to be measured with reflective film or similar material,
- or making measurements on small objects in front of a beam absorbing background, e.g. black felt.

Save and load the focus position

A focus position for the scanning head set using the controller can be saved in a flash memory in the controller and can be loaded again. To do so, proceed as follows:

1. Open the main menu by pressing ☰.
2. Use ⇩⇧ to select the menu Sensor and confirm with ↵.

   The page Sensor *is displayed.*
3. On this page use ⇩⇧ to select the menu item Auto & Remote Focus and confirm with ↵.

   The page Sensor [Auto&Remote Focus] *is displayed.*
4. On this page use ⇩⇧ to select the parameter Save Focus Position and activate it by pressing ↵.

   The current focus position is saved in a flash memory in the controller.

> **NOTE !**
>
> The focus position is only saved while the controller is switched on. If you want the focus position to be saved permanently, you have to save the focus position and then the complete settings of the controller as described in APPENDIX 5.15.6.

5. To load a saved focus position again, on the same page Sensor [Auto&Remote Focus] select the parameter Load Focus Position and activate it by pressing↵.

   The most recently saved focus position is read from the memory and the optics travel to the corresponding position.

5.15.4 Changing Settings

To change a setting, first of all you have to activate the corresponding parameter on the display. After that you can change the value and confirm the change. To do so, proceed as follows:

1. Press the keys ⇩⇧ until the selection point is next to the parameter you want to change.
2. Press the key ↵ to activate the parameter.

   The parameter is given a dark background, the arrows on the middle keys change to ⬆⬇ and the icon ↵ is replaced by ☑.
3. Now change the parameter by pressing the keys ⬆⬇.
4. When the parameter has the required value, confirm the changing by pressing the key ☑.

   The background of the parameter and the arrows turn white again and the icon ☑ is replaced again by ↵. The change is now effective.

> **NOTE !**
>
> If after activating a parameter you do not press any key on the controller for a while, then the activation is automatically reversed again after approx. five seconds!

Set the velocity decoder

To select the most suitable velocity decoder, please proceed as follows:

1. Open the main menu by pressing ☰.
2. Use ⇩⇧ to select the menu Settings and confirm with ↵.

   The page Settings *is displayed. This page shows a graphic representation of the panel of connectors on the front panel of the controller.*
3. Use ⇩⇧ to move the selection point to be next to the jack OUTPUT in the field VELOCITY or next to the jack OUTPUT in the field AUXILIARY if an auxiliary velocity decoder is installed, and confirm with ↵.

   The page Settings [Velocity OUTPUT] *or* Settings [Auxiliary] *respectively is displayed.*
4. On this page, use ⇩⇧ to select the parameter Decoder and activate it by pressing ↵.
5. Now press ⬆⬇ to select the desired velocity decoder and confirm with ☑.

This selection does not exist for the page Settings [Velocity DSP OUT], as it is only active if both the digital velocity decoder VD-07/VD-08 **and** the optional adaptive DSP filter are installed.

NOTE !

Only for PSV-400-H4: When the VD-03 is activated, you should switch off the digital decoder VD-08, as otherwise high-frequency noise peaks can occur in the spectrum of the velocity signal. Please see the section Switch of the VD-07/VD-08 on this.

Set the measurement range

To select the measurement range for velocity acquisition, proceed as follows:

1. Open the main menu by pressing ▤.
2. Use ⇩⇧ to select the menu Settings and confirm with ↵.

   The page Settings *is displayed. This page shows a graphic representation of the panel of connectors on the front panel of the controller.*
3. Use ⇩⇧ to move the selection point to be next to the jack OUTPUT in the field VELOCITY or next to the jack OUTPUT in the field AUXILIARY if an auxiliary velocity decoder is installed, and confirm with ↵.

   The page Settings [Velocity OUTPUT] *or* Settings [Auxiliary] *respectively is displayed.*
4. On this page use ⇩⇧ to select the parameter Range and activate it by pressing ↵.
5. Now use ⬆⬇ to select the desired measurement range and confirm with ☑

Set the tracking filter

To select the tracking filter mode for displacement acquisition, please proceed as follows:

1. Open the main menu by pressing ▤.
2. Use ⇩⇧ to select the menu Settings and confirm with ↵.

   The page Settings *is displayed. This page shows a graphic representation of the panel of connectors on the front panel of the controller.*
3. Use ⇩⇧ to move the selection point to be next to the jack OUTPUT in the field VELOCITY and confirm with ↵.

   The page Settings [Velocity OUTPUT] *is displayed.*
4. On this page, use ⇩⇧ to select the parameter Tracking Filter and activate it by pressing ↵.
5. Now use ⬆⬇ to select the desired tracking filter mode and confirm with ☑.

Set the low pass filter

To set the analog low pass filter, please proceed as follows:

1. Open the main menu by pressing ☰.
2. Use ⇩⇧ to select the menu Settings and confirm with ↵.

   The page Settings *is displayed. This page shows a graphic representation of the panel of connectors on the front panel of the controller.*
3. Use ⇩⇧ to move the selection point to be next to the jack OUTPUT in the field VELOCITY and confirm with ↵.

   The page Settings [Velocity OUTPUT] *is displayed.*
4. On this page, use ⇩⇧ to select the parameter LowPass Filter and activate it by pressing ↵.
5. Now use ⬆⬇ to select the desired cutoff frequency and confirm with ☑.

Set the high pass filter

To switch the high pass filter on or off, please proceed as follows:

1. Open the main menu by pressing ☰.
2. Use ⇩⇧ to select the menu Settings and confirm with ↵.

   The page Settings *is displayed. This page shows a graphic representation of the panel of connectors on the front panel of the controller.*
3. Use ⇩⇧ to move the selection point to be next to the jack OUTPUT in the field VELOCITY and confirm with ↵.

   The page Settings [Velocity OUTPUT] *is displayed.*
4. On this page, use ⇩⇧ to select the parameter HighPass Filter and activate it by pressing ↵.
5. Now use ⬆⬇ to switch the high pass filter on (100 Hz) or off (Off) and confirm with ☑.

Deactivate S/P-DIF data (only VD-07/ VD-08)

The output data from the digital velocity decoder VD-07/ VD-08 can be made available as a digital data stream via the S/P-DIF interface on the back of the controller. However, in unfavorable conditions, the high-frequency pulses from this digital data can cause distortions in the analog signal of the VD-07/ VD-08. For this reason you should always deactivate making S/P-DIF data available, if you do not use the S/P-DIF interface.

To deactivate the S/P-DIF data, proceed as follows:

1. Open the main menu by pressing ▤.
2. Use ⇩⇧ to select the menu Setup and confirm with ↵.

   The page Setup *is displayed.*
3. On this page use ⇩⇧ to select the menu item Digital Out (rear) and confirm with ↵.

   The page Setup [Digital Out] *is displayed*
4. On this page, use ⇩⇧ to select the parameter Data Rate and activate it by pressing ↵.
5. Now press ⇧⇩ to select the entry Off and confirm with ☑.

   Now no more S/P-DIF data is made available so that there is no danger of high-frequency distortions in the analog signal of the VD-07/VD-08.

Switch off the VD-07/VD-08

For measurements with the analog velocity decoder VD-03, you should not only deactivate making the S/P-DIF data available, but should also switch off the digital velocity decoder VD-08. If the VD-08 stays switched on during an analog measurement, high-frequency noise peaks can appear in the spectrum of the analog velocity signal.

To switch off the digital velocity decoder VD-08, please proceed as follows:

1. Open the main menu by pressing ▤.
2. Use ⇩⇧ to select the menu Settings and confirm with ↵.

   The page Settings *is displayed. This page shows a graphic representation of the panel of connectors on the front panel of the controller.*
3. Use ⇩⇧ to move the selection point to be next to the jack OUTPUT in the field VELOCITY and confirm with ↵.

   The page Settings [Velocity OUTPUT] *is displayed.*
4. On this page use ⇩⇧ to select the parameter Range and activate it by pressing ↵.

5. Now press ⇧⇩ to select the entry Off and confirm with ☑.

   The digital velocity decoder VD-08 is now switched off.

6. You can switch the digital velocity decoder on again by selecting the parameter Range and setting a measurement range.

Use digital output signals (only VD-07/ VD-08)

The data from the digital velocity decoder VD-07/ VD-08 is emitted as a digital data stream in S/P-DIF format on the back panel of the controller. The data is available as an optical signal at the TOSLINK jack Optical and also as an electrical signal at the TRIAX jack Electrical in the field DIGITAL OUT on the back of the controller.

Digital recording or analysis equipment connected to the digital output should support 24 bit format to obtain an optimal signal-to-noise ratio. To evaluate the digital velocity signal, you can for example use a commercially available PC sound card with an S/P-DIF input. To avoid measurement errors, you should make sure when choosing the PC sound card that the card does not automatically carry out amplitude reduction.

If required, you can get recommendations for suitable PC sound cards and software from your nearest Polytec representative.

Set the data rate (only VD-07/ VD-08)

As a general rule, the digital output signals of the VD-07/ VD-08 are available with two different data rates (48 kSa/s and 96 kSa/s). The data rate you use depends on which data rate the digital analysis systems you are using can work with.

To set the data rate, please proceed as follows:

1. Open the main menu by pressing ☰.

2. Use ⇩⇧ to select the menu Setup and confirm with ↵.

   The page Setup *is displayed.*

3. On this page use ⇩⇧ to select the menu item Digital Out (rear) and confirm with ↵.

   The page Setup [Digital Out] *is displayed.*

4. On this page, use ⇩⇧ to select the parameter Data Rate and activate it by pressing ↵.

5. Now use ⇧⇩ to select the data rate and confirm with ☑.

   The S/P-DIF data of the VD-07/ VD-08 is now available at the data rate you have selected at both jacks in the field DIGITAL OUT on the back of the controller. If you selected the entry Off, *then the S/P-DIF interface is not active.*

Alternatively the data rate can also be set on the page Settings [Velocity DSP OUT]. To do so, proceed as follows:

1. Open the main menu by pressing ☰.

2. Use ⇩⇧ to select the menu Settings and confirm with ↵.

   The page Settings *is displayed. This page shows a graphic representation of the panel of connectors on the front panel of the controller.*

3. Use ⇩⇧ to move the selection point to be next to the jack DSP OUT in the field VELOCITY and confirm with ↵.

   The page Settings [Velocity DSP Output] *is displayed.*

4. On this page, use ⇩⇧ to select the parameter Data Rate and activate it by pressing ↵.

5. Now use ⬆⬇ to select the data rate and confirm with ☑.

It makes no difference which of these two options you use to set the data rate as they are automatically aligned.

5.15.5 Saving and Loading Settings

The controller provides you with the option of saving three different settings to load them more quickly again later. Before switching off the controller you can select which settings the controller should use when you start it again. If you have operated the controller via the software, next time the controller starts always with the default settings.

Save settings

To save settings, please proceed as follows:

1. Open the main menu by pressing the key ☰.

2. Use the keys ⇩⇧ to select the menu Setup and confirm by pressing the key ↵.

   The page Setup *is displayed.*

3. On this page use the keys ⇩⇧ to select the menu item PowerUp Mode and confirm by pressing the key ↵.

   The page Setup [PowerUp Mode] *is displayed.*

4. On this page use the keys ⇩⇧ to select the parameter PowerUp Settings and activate it by pressing the key ↵.

5. Now by pressing the keys ⬆⬇ select a name it is to be saved under (User1, User2 or User3) and confirm the name by pressing the key ☑.

6. Now use the keys ⇩⇧ to select the parameter Save User Settings and activate it by pressing the key ↵.

   The current settings are now saved under the name you have selected.

Load settings To load settings you have already saved, proceed as follows:

1. Open the main menu by pressing the key ☰.
2. Use the keys ⇩⇧ to select the menu Setup and confirm by pressing the key ↵.
   The page Setup *is displayed.*
3. On this page use the keys ⇩⇧ to select the menu item PowerUp Mode and confirm by pressing the key ↵.
   The page Setup [PowerUp Mode] *is displayed.*
4. On this page use the keys ⇩⇧ to select the parameter PowerUp Settings and activate it by pressing the key ↵.
5. Now press the keys ⬆⬇ to select the name the settings were saved under (User1, User2 or User3) and confirm the name by pressing the key ✓.
   The next time you switch it on, the controller will start up with the settings you saved under the selected name.

Default settings The controller can also be started with the default settings instead of the settings you have saved under a particular name. To do so, you proceed in exactly the same way as you would for loading saved settings, but instead of selecting one of the three names you have saved under, select the entry Default.

Settings last used The controller can also be started with the settings you last used instead of the settings you have saved under a particular name. To do so, you proceed in exactly the same way as you would for loading saved settings, but instead of selecting one of the three names you have saved under, select the entry Last.

5.15.6 Messages on the Display

Messages which appear on the display of the controller are divided into three categories:

Note Messages in the category Note are identified by **(i)**. These messages provide information on activities of the controller as a consequence of the settings just made.

Warning Messages in the category Warning are identified by **(!)**. These messages are errors which you can rectify yourself, such as the scanning head accidentally not being connected up.

InSECTION 6.4 you will find all error messages, their possible causes and tips on how to rectify them.

Error Messages in the category Error are identified by (x). These messages inform you about serious instrument errors. If such an error occurs, please make a note of the contents of the message and contact your nearest Polytec representative.

All messages on the display are closed again by pressing any of the function keys.

5.15.7 Displaying the Configuration and the Firmware Version of the Controller

Firmware version The current firmware version is shown on the display shortly after switching the controller on. After a few seconds the displayed information disappears again.

Configuration You can show the configuration of the controller on the display. To do so, proceed as follows:

1. Open the main menu by pressing ☰.
2. Use ⇩⇧ to select the menu Setup and confirm with ↵.
   The page Setup *is displayed.*
3. On this page use ⇩⇧ to select the menu item Service and confirm with ↵.
   The page Setup [Service] *is displayed.*
4. Now use ⇩⇧ to select the parameter Obligatory Components for the standard components of the controller and confirm with ↵.
   The page [...Obligatories] *with the standard components is displayed.*
5. Go back to the page Setup [Service] by selecting the menu item Back from the main menu (key ☰) and confirm (key ↵).

6. Now use ⇩⇧ to select the parameter Optional Components for the optional components and confirm with ↵.

   The page [...Options] *with the optional components installed is displayed.*

5.16 Configuring the RS-232 Interface of the Controller

You can use the display to configure the RS-232 interface on the back of the controller. To do so, proceed as follows:

1. Open the main menu by pressing ☰.
2. Use ⇩⇧ to select the menu Setup and confirm with ↵.

   The page Setup *is displayed.*
3. On this page use ⇩⇧ to select the menu item Interface (rear) and confirm with ↵.

   The page Setup [Interface] *is displayed.*
4. On this page, use ⇩⇧ to select the parameter Baud Rate and activate it by pressing ↵.
5. Now use ⬆⬇ to select the transfer rate and confirm with ☑.
6. On the page Setup [Interface] use ⇩⇧ to select the parameter Echo Mode and activate it by pressing ↵.
7. Now use ⬆⬇ to switch the echo off (Off) or on (On) and confirm with ☑.

> **NOTE !**
>
> For all PSV models, here the transfer rate **must** be set to **115200 Baud!**

6 Fault Diagnosis

Simple tests are described in the following for you to carry out yourself in the case of malfunction. In the case of more difficult problems with the individual functions, please contact our service personnel. The tests described here are not meant to lead you to carry out maintenance work yourself, but to provide our service personnel with information which is as accurate as possible.

Testing the PSV is limited to such tests in which the housing do not have ti be opened. Opening the housings without authorization will invalidate the warranty.

If required, please contact our service department. Based on your fault description, further procedure will be determined.

If the PSV has to be sent back for repair, always use the original packaging and enclose an exact description of the fault.

6.1 General Tests

If any system component of the PSV does not function properly, please first check the following:

1. Is the PSV cabled correctly as described in SECTION 3.4.2?

Controller

2. Is there only the original RS-232(X) cable (cross-wired) from Polytec used?
3. Is the transfer rate set to 115200 Baud (refer to SECTION 5.16)?

> **NOTE !**
>
> For all PSV models, here the transfer rate **must** be set to **115200 Baud!**

4. Is the key switch on the front of the controller in position I?
5. Is the LED POWER on the front of the controller lit up?

   If the LED is not lit up, it can be assumed that there is a fault in the mains supply. Disconnect the mains plug and check the fuses on the back of the controller. Please note that there are two active fuses which can both bead to failure.

> **WARNING !**
>
> **Danger from electrical current!** - Working on an open housing can lead to personal injury!

> **NOTE !**
>
> Before checking the fuses, the mains plug must be disconnected!

6. Is the LED POWER on the front of the junction box lit up?

   The junction box will be automatically switched on with the controller, assuming the interferometer cable is installed correctly. If the LED is not lit up, it can be assumed that there is a fault in the mains supply. Disconnect the mains plug and check the fuses on the back of the junction box. Please note that there are two active fuses which can both bead to failure.

Check whether the data acquisition board is installed correctly. To do so, proceed as follows:

7. Switch the PC on.

Data acquisition board for models -H4, -M2, -M4, -B

8. Double-click the icon Measurement&Automation on the desktop.
9. Change into the directory Devices and Interfaces.

   The data acquisition board is installed correctly, if in the directory according to the model PCI-4461, PCI-4462, PCI-6110 or PCI-6111 is listed. If not, there is a problem with the data acquisition board.

   If you operate the PSV-400-H4 with the optional junction box PSV-E-408, your PC is equipped with two data acquisition boards. These are shown twice as PCI-4462 in the directory *Devices and Interfaces.*

NOTE !

The data acquisition board and the generator board are shown in a defined order (Value), which **never** has to be changed !

Generator board for model -H4

The generator board is installed correctly, if in the directory according to the model PCI-6711 is listed. If not, there is a problem with the generator board.

Data acquisition board for model -M2-20

10. Open the Device Manager of your operating system. You will find detailed information on this in the manual of the operating system.

    The data acquisition board and the generator board are installed correctly if they are listed in the Device Manager. if not, please press the key F5 on your keyboard to refresh your display. If the data acquisition board and the generator board are not yet listed, please check whether the boards are properly inserted into their slots in the PC.

6.2 Problems with the Laser

6.2.1 No Laser Beam

If no laser beam is emitted, check the following:

1. Is the PSV cabled correctly as described in SECTION 3.4.2?
2. Is the key switch on the front of the controller in position I?
3. Is the beam shutter on the front of the scanning head open (position ON)?
4. Is the LED LASER on the back of the scanning head lit up?

   If the LED is not lit up, it can be assumed that there is a fault in the mains supply of the controller. In this case disconnect the mains plug and check the fuses on the back panel. Please note that there are two active fuses which can both bead to failure.

> **WARNING !**
>
> **Danger from electrical current!** - Working on an open housing can lead to personal injury!

> **NOTE !**
>
> Before checking the fuses, the mains plug must be disconnected!

5. Is the LED POWER on the front of the junction box lit up?

   If not, it can be assumed that there is a fault with the power supply of the junction box. In this case disconnect the mains plug and check the fuses on the back panel. Please note that there are two active fuses which can both bead to failure.

> **WARNING !**
>
> **Danger from electrical current!** - Working on an open housing can lead to personal injury!

> **NOTE !**
>
> Before checking the fuses, the mains plug must be disconnected!

6.2.2 Great Fluctuation of the Signal Level Display

If the signal level display on the back of the scanning head or in the software fluctuates a lot periodically, please check the following:

Is the object positioned unfavorably in a visibility minimum of the laser?

Change the distance between the scanning head and the object. You will find detailed information on optimal stand-off distance and visibility maxima of the scanning head in SECTION 4.3 or SECTION 7.6.2.

6.2.3 Laser can not be Focused using the Hand Set PSV-Z-051

If the laser beam can not be focused remotely with the hand set PSV-Z-051, please check the following:

Has the controller the firmware version V1.2 (refer to SECTION 5.15.7) and at least the PSV software 8.1 installed on the PC?

If not, you have to update your PSV software and the firmware of the controller. Please contact Polytec on this.

6.3 No Measurement Signal or Implausible Measurement Signals

If the laser beam is emitted but there is no measurement signal, please check the following:

1. Is the PSV cabled correctly as described in SECTION 3.4.2?
2. Put a matt white test surface such as a piece of paper at approximately 50 cm from the front panel of the scanning head in the beam path. Does the signal level display lit up?

   If the signal level display does not light up, then the input section of the controller is faulty.

Check the correct function of the data acquisition board and the software as follows:

Data acquisition

1. Disconnect the BNC cable for the measurement signal from the BNC jack VELO on the front of the junction box.
2. Feed the signal of a function generator to this BNC jack.
3. Display the time signal in an analyzer as described in your software manual.

   The data acquisition board and the software work properly, if the signal of the function generator is displayed correctly. In this case there is a problem in the controller.

Output signal

Now check the output signal of the controller as follows:

4. Display the time signal in an analyzer as described in your software manual.
5. Set the measurement range to $10\frac{mm}{s}/V$. Does the output signal react to the test surface moving?
6. If the output signal does not react, check if a significant offset is indicated.

   Normally a DC voltage less than ±50 mV can be measured.

6.4 Messages on the Display of the Controller

Messages which appear on the display of the controller are divided into three categories:

Note

Messages in the category Note are identified by **(i)**. These messages provide information on activities of the controller as a consequence of the settings just made.

You will find a list of all notes with explanations in SECTION 6.4.1.

Warning

Messages in the category Warning are identified by **(!)**. These messages are errors which you can rectify yourself, such as the scanning head accidentally not being connected up.

You will find a list of all warnings with explanations in SECTION 6.4.2.

Error

Messages in the category Error are identified by**(x)**. These messages inform you about serious instrument errors. If such an error occurs, please make a note of the contents of the message and contact your nearest Polytec representative.

You will find a list of all errors with explanations in SECTION 6.4.3.

All messages on the display are closed again by pressing any of the function keys.

6.4.1 List for Notes (i)

Message	Explanation
(i) Last settings cannot be saved. This is done automatically.	The current settings on the controller are saved permanently. They therefore do not have to be saved before switching off.
(i) Default settings are predefined and cannot be saved.	The default settings can not be overwritten.
(i) Settings saved successfully as UserX	The current settings have now been saved under the name you have selected.
(i) Keyboard is locked by Interface Control.	The keys on the front panel of the controller are locked when controller is remotely operating via the software.
(i) Filter Response Saved. Use Range 'Load Response' to recall.	The current frequency response is saved with the frequency range set in the flash memory of the DSP filter. You can recall the saved settings via Range 'Load Response'.
(i) Focus Position Saved	The actual focus position is saved.

6.4.2 List for Warnings

Message	Explanation
(!) Component is not installed.	The selected menu item is not available as the necessary hardware component has not been installed, e.g. Save Filter Coefficients with the DSP filter is not installed.
(!) No Sensor Head found.	**Scanning headPSV-I-400:** The scanning head has not been connected or is connected wrongly or the connecting cable is defective. Check that the connecting cable between the controller and the scanning head is connected up correctly. **Other sensor heads:** All other sensor heads can not yet be remotely controlled from the controller. So the controller can not recognize them yet either.
(!) Hardware has changed. PowerUp Mode and all settings are now set to defaults!	This message appears after installing new components in the controller. After such an installation, the whole instrument is set back to the default settings. The message only appears the first time you switch on after the installation.
(!) Non-volatile storage is only possible with PowerUp Settings 'Last'	The current focus position can only be saved in the Power-Up mode Last. First of all, save the focus position in the Power-Up mode Last. Then change the Power-Up mode to User1, User2 or User3 and save the settings (refer to SECTION 5.15.6).
(!) Saving is not possible in this range.	To save frequency response with the frequency range set of the DSP filter ('Save Response'), you have to select one of the three frequency ranges (Range '< 20kHz', '< 2kHz' or '< 0.3kHz').

6.4.3 List for Error

Message	Explanation
(x) Error @ I2C address:0xXX	After installing a new hardware component a hardware conflict has occurred. It is possible that the new hardware component has not been configured correctly. **Please contact our service department!**
(x) Error on SCI 0 (x) Error on SCI 1 (x) Error on SCI 2 (x) Error on I2C Bus (x) Error on ADC	An internal error has occurred. **Please contact our service department!**

7 Technical Specifications

7.1 Standards Applied

Laser safety:	IEC/EN 60825-1:2003-10 (safety of laser products, complies to US 21 CFR 1040.10 and 1040.11 except for deviations pursuant to laser notice no. 50, dated 26 July 2001)
Electrical safety:	IEC/EN 61010-1:2002-08 (safety requirements for electrical equipment for measurement, control and laboratory use)
EMC:	IEC/EN 61326-1:2006-10 (EMC requirements on Emission and Immunity - electrical equipment for measurement, control and laboratory use) Emission: FCC Class B IEC/EN 61000-3-2 and 61000-3-3 Immunity: IEC/EN 61000-4-2 to 61000-4-6 and IEC/EN 61000-4-11

7.2 Controller OFV-5000

7.2.1 General Data

Mains Connection

Mains voltage:	100...240VAC ±10%, 50/60Hz
Power consumption:	max. 100VA
Fuses:	2.0A/slow-blow
Safety class:	I (protective grounding)

Ambient Conditions

Operating temperature:	+5°C...+40°C (41°F...104°F)
Storage temperature:	−10°C...+65°C (14°F...149°F)
Operating altitude:	0m...3048m (0ft...10000ft)
Relative humidity:	max. 80%, non-condensing

Housing

Dimensions:	450mm x 360mm x 150mm (19", 84HE/3U)
Weight:	10kg

Calibration

Calibration recommended:	every 2 years

7.2.2 Digital Interfaces

RS-232:	8 data bit, 1 stop bit, no parity; Baud rate: 115200 Baud (for PSV); RS-232(X) cable to the junction box: 2 x 9 pin Sub-D jack, null modem cable (cross-wired)
DIGITAL OUT Optical:	TOSLINK output with S/P-DIF standard (not active for PSV-400-B and PSV-400-M2-20)
DIGITAL OUT Electrical:	TRIAX output with S/P-DIF standard (not active for PSV-400-B and PSV-400-M2-20)
External Decoder:	Special interface for an external digital displacement decoder

7.2.3 Analog Signal Inputs and Outputs

VELOCITY OUTPUT

Voltage output for the velocity signal

Output swing:	max. $20 V_{p\text{-}p}$
Output impedance:	nom. 50 Ω
Load resistance:	min. 10 Ω (−0.5% additional error)
Overrange indicator threshold:	typ. 90% of full scale
DC offset:	max. 20 mV

VELOCITY DSP OUT

Voltage output for the velocity signal after adaptive DSP filtering (only for a connection along with the adaptive DSP filter LF-02)

Output swing:	max. $20 V_{p\text{-}p}$
Output impedance:	nom. 50 Ω
Load resistance:	min. 10 Ω (−0.5% additional error)
DC offset:	max. 10 mV

AUXILIARY OUTPUT

Voltage output of the signal of the optional auxiliary decoder (displacement or velocity signal depending on the decoder)

Electrical properties:	Depending on the decoder installed (refer to SECTION 7.2.4)

AUXILIARY UNIVERSAL

Input or output for special functions of the optional auxiliary decoders

DISPLACEMENT OUTPUT

Voltage output for the displacement signal (only with a displacement decoder installed)

Output swing:	max. 20 V_{p-p} (depending on the displacement decoder)
Output impedance:	nom. 50 Ω
Load resistance:	min. 10 Ω (−0.5% additional error)

DISPLACEMENT TRIG IN

Trigger input to set the DC offset of the displacement signal back to zero (only with a displacement decoder installed)

Input voltage:	max. ±15 V
Sensitivity threshold:	< 25 mV (rising edge)
Input impedance:	min. 10 kΩ
Pulse width:	min. 2 µs
Pulse frequency:	max. 100 kHz
Trigger delay:	< 10 µs (typ. 5 µs)

SIGNAL

Signal output for a DC voltage signal proportional to the logarithm of the optical signal level

Voltage range:	0 V...3 V, DC
Load resistance:	≥10 kΩ

7.2.4 Decoder Specified Properties

Velocity Decoder VD-03 (PSV-400-H4)

Measurement range	10	100	1000	$\frac{mm}{s}$/V
Full scale (peak)	0.1	1	10	m/s
Frequency range				
f_{min}	0.5	0.5	0.5	Hz
f_{max}	250	1500	1500	kHz
Max. acceleration	16000	960000	9600000	g
Frequency response[1]				
0.5Hz...20Hz	±0.5	±0.5	±0.5	dB
20Hz...100Hz	±0.1	±0.1	±0.1	dB
100Hz...250kHz	+0.2/−1	±0.1	±0.1	dB
250kHz...1.5MHz	-	+0.5/−2	+0.5/−2	dB
Resolution[2]				
frequency-dependent[3]	0.1...1	0.3...3	2...5	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	0.2	0.5	2.5	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−2.12	−0.41	−0.36	°/kHz
Signal delay t_D (typ.)	5.89	1.15	0.99	µs
Calibration error[5]				
T_a = (25 ±3)°C (T_a = (77 ±5)°F)	±1	±1	±1	%
T_a = +5°C...+40°C (T_a = 41°F...104°F)	±1.5	±2.5	±2.5	%
Linearity error[6]	1	1	1	%
Harmonic distortions	< −52	< −50	< −50	dBc
Spurious signals (non-harmonic)[7]	< −86	< −86	< −86	dBFS

[1] The frequency response defines the frequency-dependent amplitude error, referred to the reference frequency of 1kHz.

[2] The noise-limited resolution is defined as the signal amplitude (rms) at which the signal-to-noise ratio is 0dB with 1Hz spectral resolution, measured on 3M ScotchliteTape® (reflective film).

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10Hz.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1kHz, amplitude 70% of full scale range, load resistance ≥ 1MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote[5]).

[7] The maximum amplitude of the distortion refers to the full scale. An exception of which is a single peak, generated by the optical sensor, in the frequency region 20...25kHz, whose amplitude depends on the stand-off distance.

Velocity Decoder VD-04 (PSV-400-B)

Measurement range	10	100	1000	$\frac{mm}{s}/V$
Full scale (peak)	0.1	1	10	m/s
Frequency range				
f_{min}	0.5	0.5	0.5	Hz
f_{max}	250	250	250	kHz
Max. acceleration	16000	160000	1600000	g
Frequency response[1]				
0.5Hz...20Hz	±0.5	±0.5	±0.5	dB
20Hz...100Hz	±0.1	±0.1	±0.1	dB
100Hz...200kHz	±0.2	±0.2	±0.2	dB
200kHz...250kHz	±0.2/−1	+0.1/−1	+0.1/−1	dB
Resolution[2]				
frequency-dependent[3]	0.1...1	0.3...3	2...5	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	0.2	0.5	2.0	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−2.11	−1.52	−1.46	°/kHz
Signal delay t_D (typ.)	5.85	4.21	4.05	μs
Calibration error[5]				
T_a = (25 ±3)°C (T_a = (77 ±5)°F)	±1	±1	±1	%
T_a = +5°C...+40°C (T_a = 41°F...104°F)	±1.5	±2.5	±2.5	%
Linearity error[6]	1	1	1	%
Harmonic distortions	< −52	< −50	< −50	dBc
Spurious signals (non-harmonic)[7]	< −86	< −86	< −86	dBFS

[1] The frequency response defines the frequency-dependent amplitude error, referred to the reference frequency of 1kHz.

[2] The noise-limited resolution is defined as the signal amplitude (rms) at which the signal-to-noise ratio is 0dB with 1Hz spectral resolution, measured on 3M ScotchliteTape® (reflective film).

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10Hz.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1kHz, amplitude 70% of full scale range, load resistance ≥ 1MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote[5]).

[7] The maximum amplitude of the distortion refers to the full scale. An exception of which is a single peak, generated by the optical sensor, in the frequency region 20...25kHz, whose amplitude depends on the stand-off distance.

Velocity Decoder VD-07 (Part 1 of 2, only PSV-400-M2, -M4 and -M2-20)

Measurement range	1	2	5 (LP)	5	$\frac{mm}{s}/V$
Full scale (peak)	0.01	0.02	0.05	0.05	m/s
Frequency range					
f_{min}	0	0	0	0	Hz
f_{max}	20	20	20	100	kHz
Max. acceleration	128	256	640	3200	g
Frequency response[1]					
0.05 Hz ... 10 kHz	±0.05	±0.05	±0.05	-	dB
10 kHz ... 14 kHz	+0.1/−0.3	+0.1/−0.3	+0.1/−0.3	-	dB
14 kHz ... 20 kHz	+0.1/−1	+0.1/−1	+0.1/−1	-	
0.05 Hz ... 40 kHz	-	-	-	±0.05	
40 kHz ... 75 kHz	-	-	-	+0.1/−0.3	
75 kHz ... 100 kHz	-	-	-	+0.1/−1	
Resolution[2]					
frequency-dependent[3]	< 0.02	< 0.02	< 0.02	0.01 ... 0.04	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	0.01	0.01	0.01	0.02	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−46.3	−45.8	−45.0	−4.6	°/kHz
Signal delay t_D (typ.)	128	127	125	12.7	µs
Calibration error[5] T_a = +5°C ... +40°C (T_a = 41°F ... 104°F)	±1	±1	±1	±1	%
Linearity error[6]	< 0.1	< 0.1	< 0.1	< 0.1	%
Harmonic distortions	< −54	< −54	< −54	< −44	dBc
Spurious signals (non-harmonic)[7]	< −74	< −80	< −83	< −83	dBFS

[1] The frequency response defines the frequency-dependent amplitude error, referred to the reference frequency of 1kHz.

[2] The noise-limited resolution is defined as the signal amplitude (rms) at which the signal-to-noise ratio is 0dB with 1Hz spectral resolution, measured on 3M ScotchliteTape® (reflective film).

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10Hz. In the frequency range from 10Hz to 5kHz the specified decoder noise is superimposed by scanner noise. The resolution is then between 0.1 and 1 µm/s with 1 Hz spectral resolution.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1 kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote[5]).

[7] The maximum amplitude of the distortion refers to the full scale. An exception of which is a single peak, generated by the optical sensor, in the frequency region 20 ... 25 kHz, whose amplitude depends on the stand-off distance.

Velocity Decoder VD-07 (Part 2 of 2, only PSV-400-M2, -M4 and -M2-20)

Measurement range	10 (LP)	10	20	50	mm/s/V
Full scale (peak)	0.1	0.1	0.2	0.5	m/s
Frequency range					
f_{min}	0	0	0	0	Hz
f_{max}	100	350	350	350	kHz
Max. acceleration	6400	22000	44000	110000	g
Frequency response[1]					
0.05 Hz...40 kHz	±0.05	-	-	-	dB
40 kHz...75 kHz	+0.1/−0.3	-	-	-	dB
75 kHz...100 kHz	+0.1/−1	-	-	-	
0.05 Hz...200 kHz	-	± 0.05	± 0.05	± 0.05	
200 kHz...300 kHz	-	+0.1/−0.3	+0.1/−0.3	+0.1/−0.3	
300 kHz...350 kHz	-	+0.1/−1	+0.1/−1	+0.1/−1	
Resolution[2]					
frequency-dependent[3]	0.01...0.04	0.01...0.1	0.02...0.1	0.04...0.2	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	0.02	0.05	0,06	0.06	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−4.6	−3.9	−3.9	−3.9	°/kHz
Signal delay t_D (typ.)	12.7	10.9	10.9	10.9	µs
Calibration error[5] T_a = +5°C...+40°C (T_a = 41°F...104°F)	±1	±1	±1	±1	%
Linearity error[6]	< 0.1	< 0.1	< 0.1	< 0.1	%
Harmonic distortions	< −50	< −50	< −52	< −52	dBc
Spurious signals (non-harmonic)[7]	< −86	< −86	< −90	< −90	dBFS

[1] The frequency response defines the frequency-dependent amplitude error, referred to the reference frequency of 1kHz.

[2] The noise-limited resolution is defined as the signal amplitude (rms) at which the signal-to-noise ratio is 0dB with 1Hz spectral resolution, measured on 3M ScotchliteTape® (reflective film).

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10Hz. In the frequency range from 10Hz to 5kHz the specified decoder noise is superimposed by scanner noise. The resolution is then between 0.1 and 1 µm/s with 1 Hz spectral resolution.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1 kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote[5]).

[7] The maximum amplitude of the distortion refers to the full scale. An exception of which is a single peak, generated by the optical sensor, in the frequency region 20...25kHz, whose amplitude depends on the stand-off distance.

Velocity Decoder VD-08 (Part 1 of 2, only PSV-400-H4)

Measurement range	0.2	0.5	1	2	$\frac{mm}{s}/V$
Full scale (peak)	0.002	0.005	0.01	0.02	m/s
Frequency range					
f_{min}	0	0	0	0	Hz
f_{max}	5	5	10	20	kHz
Max. acceleration	6.4	16	64	256	g
Frequency response[1]					
0.05 Hz ... 3 kHz	±0.05	±0.05	-	-	dB
3 kHz ... 4 kHz	+0.1/−0.3	+0.1/−0.3	-	-	dB
4 kHz ... 5 kHz	+0.1/−1	+0.1/−1	-	-	dB
0.05 Hz ... 7 kHz	-	-	±0.05	-	dB
7 kHz ... 8 kHz	-	-	+0.1/−0.3	-	dB
8 kHz ... 10 kHz	-	-	+0.1/−1	-	dB
0.05 Hz ... 10 kHz	-	-	-	±0.05	dB
10 kHz ... 14 kHz	-	-	-	+0.1/−0.3	dB
14 kHz ... 20 kHz	-	-	-	+0.1/−1	dB
Resolution[2]					
frequency-dependent[3]	< 0.01	< 0.01	< 0.02	< 0.02	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	< 0.005	< 0.005	< 0.01	< 0.01	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−107	−107	−105	−49.3	°/kHz
Signal delay t_D (typ.)	297	297	290	137	µs
Calibration error[5] T_a = +5°C ... +40°C (T_a = 41°F ... 104°F)	±1	±1	±1	±1	%
Linearity error[6]	< 0.1	< 0.1	< 0.1	< 0.1	%
Harmonic distortions	< −50	< −50	< −54	< −54	dBc
Spurious signals (non-harmonic)[7]	< −60	< −68	< −74	< −80	dBFS

[1] The frequency response defines the frequency-dependent amplitude error, referred to the reference frequency of 1kHz.

[2] The noise-limited resolution is defined as the signal amplitude (rms) at which the signal-to-noise ratio is 0dB with 1Hz spectral resolution, measured on 3M ScotchliteTape® (reflective film).

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10Hz. In the frequency range from 10Hz to 5kHz the specified decoder noise is superimposed by scanner noise. The resolution is then between 0.1 and 1µm/s with 1Hz spectral resolution.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1kHz, amplitude 70% of full scale range, load resistance ≥ 1MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote[5]).

[7] The maximum amplitude of the distortion refers to the full scale. An exception of which is a single peak, generated by the optical sensor, in the frequency region 20...25kHz, whose amplitude depends on the stand-off distance.

Velocity Decoder VD-08 (Part 2 of 2, only PSV-400-H4)

Measurement range	5	10	20	50	$\frac{mm}{s}/V$
Full scale (peak)	0.05	0.1	0.2	0.5	m/s
Frequency range					
f_{min}	0	0	0	0	Hz
f_{max}	20	20	25	25	kHz
Max. acceleration	640	1280	3200	8000	g
Frequency response[1]					
0.05 Hz ... 10 kHz	±0.05	±0.05	-	-	dB
10 kHz ... 14 kHz	+0.1/−0.3	+0.1/−0.3	-	-	dB
14 kHz ... 20 kHz	+0.1/−1	+0.1/−1	-	-	dB
0.05 Hz ... 11 kHz	-	-	±0.1	±0.1	dB
11 kHz ... 16 kHz	-	-	+0.1/−0.3	+0.1/−0.3	dB
16 kHz ... 25 kHz	-	-	+0.1/−1	+0.1/−1	dB
Resolution[2]					
frequency-dependent[3]	< 0.02	0.01 ... 0.04	0.2 ... 0.08	0.04 ... 0.2	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	0.01	0.02	0.03	0,05	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−33.8	−33.8	−8.7	−8,7	°/kHz
Signal delay t_D (typ.)	94	94	24.3	24.3	µs
Calibration error[5] T_a = +5°C ... +40°C (T_a = 41°F ... 104°F)	±1	±1	±1	±1	%
Linearity error[6]	< 0.1	< 0.1	< 0.1	< 0.1	%
Harmonic distortions	< −54	< −54	< −54	< −54	dBc
Spurious signals (non-harmonic)[7]	< −83	< −86	< −90	< −90	dBFS

[1] The frequency response defines the frequency-dependent amplitude error, referred to the reference frequency of 1kHz.

[2] The noise-limited resolution is defined as the signal amplitude (rms) at which the signal-to-noise ratio is 0dB with 1Hz spectral resolution, measured on 3M ScotchliteTape® (reflective film).

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10Hz. In the frequency range from 10Hz to 5kHz the specified decoder noise is superimposed by scanner noise. The resolution is then between 0.1 and 1 µm/s with 1 Hz spectral resolution.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1 kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote[5]).

[7] The maximum amplitude of the distortion refers to the full scale. An exception of which is a single peak, generated by the optical sensor, in the frequency region 20 ... 25 kHz, whose amplitude depends on the stand-off distance.

Velocity Decoder VD-09 (Part 1 of 4, only PSV-400-M2, -M4 and -M2-20)

Measurement range	5	10	20 (LP)	20	$\frac{mm}{s}$/V
Full scale (peak)	0.05	0.1	0.2	0.2	m/s
Frequency range					
f_{min}	0	0	0	0	Hz
f_{max}	100	250	250	1000	kHz
Max. acceleration	3200	16000	32000	128000	g
Frequency response[1]					
0.05 Hz...50 kHz	±0.1	±0.1	±0.1	±0.1	dB
50 kHz...100 kHz	+0.1/−1	+0.1/−0.2	±0.1	±0.1	dB
100 kHz...250 kHz	–	+0.1/−1	+0.1/−1	±0.1	dB
250 kHz...1 MHz	–	–	–	+0.2/−0.5	dB
Resolution[2]					
frequency-dependent[3]	0.01...0.04	0.01...0.07	0.2...0.08	0.02...0.25	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	0.02	0.04	0.05	0.12	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−7.45	−5.54	−5.8	−3.2	°/kHz
Signal delay t_D (typ.)	20.7	15.4	16.1	8.9	µs
Calibration error[5]					
T_a = (25±3)°C (T_a = (77±5)°F)	±1	±1	±1	±1	%
T_a = +5°C...+40°C (T_a = 41°F...104°F)	±1	±1	±1	±1.5	%
Linearity error[6]	0.5		0.5		%
Harmonic distortions[7]					
0.05 Hz...100 kHz	< −44	< −52	< −52	< −52	dBc
100 kHz...250 kHz	–	< −46	< −46	< −46	dBc
>250 kHz	–	–	–	< −38	dBc
Spurious signals (non-harmonic)[8]	< −83	< −86	< −90	< −90	dBFS

[1] The frequency response defines the frequency-dependent amplitude error, referred to the reference frequency of 1kHz.

[2] The noise-limited resolution is defined as the signal amplitude (rms) at which the signal-to-noise ratio is 0dB with 1Hz spectral resolution, measured on 3M ScotchliteTape® (reflective film).

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10Hz. In the frequency range from 10Hz to 5kHz the specified decoder noise is superimposed by scanner noise. The resolution is then between 0.1 and 1 µm/s with 1 Hz spectral resolution.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1 kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote[5]).

[7] Harmonic distortions are defined 70% of full scale for the wanted signal. In each case the bandwidth is specified, in which the distortion can occur.

[8] The maximum amplitude of the distortion refers to the full scale. An exception of which is a single peak, generated by the optical sensor, in the frequency region 20...25kHz, whose amplitude depends on the stand-off distance.

Velocity Decoder VD-09 (Part 2 of 4, only PSV-400-M2, -M4 and -M2-20)

Measurement range	50 (LP)	50	100 (LP)	100	$\frac{mm}{s}/V$
Full scale (peak)	0.5	0.5	1	1	m/s
Frequency range					
f_{min}	0	0	0	0	Hz
f_{max}	250	1 500	250	1 500	kHz
Max. acceleration	80 000	480 000	160 000	960 000	g
Frequency response[1]					
0.05 Hz ... 100 kHz	±0.1	±0.1	±0.1	±0.1	dB
100 kHz ... 250 kHz	+0.1/−1	±0.1	+0.1/−1	±0.1	dB
250 kHz ... 1 MHz	–	±0.2	–	±0.2	dB
1 MHz ... 1.5 MHz	–	+0.2/−0.5	–	+0.2/−0.5	dB
Resolution[2]					
frequency-dependent[3]	0.04 ... 0.2	0.04 ... 0.35	0.07 ... 0.4	0.06 ... 0.4	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	0.06	0.18	0.1	0.2	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−5.4	−2.94	−4.54	−2.94	°/kHz
Signal delay t_D (typ.)	15.0	8.16	12.6	8,16	µs
Calibration error[5]					
T_a = (25±3)°C (T_a = (77±5)°F)	±1	±1	±1	±1	%
T_a = +5°C ... +40°C (T_a = 41°F ... 104°F)	±1	±1.5	±1	±1.5	%
Linearity error[6]	0.5		0.5		%
Harmonic distortions[7]					
0.05 Hz ... 100 kHz	< −52	< −52	< −54	< −54	dBc
100 kHz ... 250 kHz	< −46	< −46	< −54	< −54	dBc
>250 kHz	–	< −36	–	< −38	dBc
Spurious signals (non-harmonic)[8]	< −90	< −90	< −90	< −90	dBFS

[1] The frequency response defines the frequency-dependent amplitude error, referred to the reference frequency of 1kHz.

[2] The noise-limited resolution is defined as the signal amplitude (rms) at which the signal-to-noise ratio is 0dB with 1Hz spectral resolution, measured on 3M ScotchliteTape® (reflective film).

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10Hz. In the frequency range from 10Hz to 5kHz the specified decoder noise is superimposed by scanner noise. The resolution is then between 0.1 and 1 µm/s with 1 Hz spectral resolution.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1 kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote[5]).

[7] Harmonic distortions are defined 70% of full scale for the wanted signal. In each case the bandwidth is specified, in which the distortion can occur.

[8] The maximum amplitude of the distortion refers to the full scale. An exception of which is a single peak, generated by the optical sensor, in the frequency region 20 ... 25kHz, whose amplitude depends on the stand-off distance.

Velocity Decoder VD-09 (Part 3 of 4, only PSV-400-M2, -M4 and -M2-20)

Measurement range	200 (LP)	200	500 (LP)	500	$\frac{mm}{s}/V$
Full scale (peak)	2	2	5	5	m/s
Frequency range					
f_{min}	0	0	0	0	Hz
f_{max}	250	2500	250	2500	kHz
Max. acceleration	320000	3200000	800000	8000000	g
Frequency response[1]					
0.05 Hz ... 100 kHz	±0.1	±0.1	±0.1	±0.1	dB
100 kHz ... 250 kHz	+0.1/−1	±0.1	+0.1/−1	±0.1	dB
250 kHz ... 1 MHz	–	±0.2	–	±0.2	dB
1 MHz ... 1.5 MHz	–	±0.2	–	±0.2	dB
1.5 MHz ... 2.5 MHz	–	+0.5/−1.5	–	+0.5/−1.5	dB
Resolution[2]					
frequency-dependent[3]	0.13 ... 0.8	0.1 ... 1	0.25 ... 2	0.25 ... 2	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	0.15	0.5	0.25	0.6	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−4.75	−1.35	−2.10	−1.34	°/kHz
Signal delay t_D (typ.)	13.2	3.76	5.83	3.73	µs
Calibration error[5]					
T_a = (25±3)°C (T_a = (77±5)°F)	±1	±1	±1	±1	%
T_a = +5°C ... +40°C (T_a = 41°F ... 104°F)	±1	±1.5	±1	±1.5	%
Linearity error[6]	0.5		0.5		%
Harmonic distortions[7]					
0.05 Hz ... 100 kHz	< −54	< −54	< −54	< −54	dBc
100 kHz ... 250 kHz	< −54	< −54	< −54	< −54	dBc
>250 kHz	–	< −38	–	< −36	dBc
Spurious signals (non-harmonic)[8]	< −90	< −90	< −90	< −90	dBFS

[1] The frequency response defines the frequency-dependent amplitude error, referred to the reference frequency of 1kHz.

[2] The noise-limited resolution is defined as the signal amplitude (rms) at which the signal-to-noise ratio is 0dB with 1Hz spectral resolution, measured on 3M ScotchliteTape® (reflective film).

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10Hz. In the frequency range from 10Hz to 5kHz the specified decoder noise is superimposed by scanner noise. The resolution is then between 0.1 and 1 µm/s with 1 Hz spectral resolution.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1 kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote[5]).

[7] Harmonic distortions are defined 70% of full scale for the wanted signal. In each case the bandwidth is specified, in which the distortion can occur.

[8] The maximum amplitude of the distortion refers to the full scale. An exception of which is a single peak, generated by the optical sensor, in the frequency region 20 ... 25 kHz, whose amplitude depends on the stand-off distance.

Velocity Decoder VD-09 (Part 4 of 4, only PSV-400-M2, -M4 and -M2-20)

Measurement range	1000 (LP)	1000	$\frac{mm}{s}$/V
Full scale (peak)	10	10	m/s
Frequency range			
f_{min}	0	0	Hz
f_{max}	250	1500	kHz
Max. acceleration	1600000	9600000	g
Frequency response[1]			
0.05 Hz...100 kHz	±0.1	±0.1	dB
100 kHz...250 kHz	+0.1/−1	±0.1	dB
250 kHz...1 MHz	–	±0.2	dB
1 MHz...1.5 MHz	–	+0.2/−0.5	dB
Resolution[2]			
frequency-dependent[3]	0.5...4	0.5...4	$\frac{\mu m}{s}/\sqrt{Hz}$
typically[4]	0.5	0.7	$\frac{\mu m}{s}/\sqrt{Hz}$
Frequency-dependent phase shift p_D (typ.)	−2.57	−2.14	°/kHz
Signal delay t_D (typ.)	7.13	5.95	µs
Calibration error[5]			
T_a = (25±3)°C (T_a = (77±5)°F)	±1	±1	%
T_a = +5°C...+40°C (T_a = 41°F...104°F)	±1	±1.5	%
Linearity error[6]	0.5		%
Harmonic distortions[7]			
0.05 Hz...100 kHz	< −54	< −54	dBc
100 kHz...250 kHz	< −54	< −50	dBc
>250 kHz	–	< −38	dBc
Spurious signals (non-harmonic)[8]	< −90	< −90	dBFS

[1] The frequency response defines the frequency-dependent amplitude error, referred to the reference frequency of 1kHz.

[2] The noise-limited resolution is defined as the signal amplitude (rms) at which the signal-to-noise ratio is 0dB with 1Hz spectral resolution, measured on 3M ScotchliteTape® (reflective film).

[3] The attainable resolution is frequency-dependent and is specified for frequencies above 10Hz. In the frequency range from 10Hz to 5kHz the specified decoder noise is superimposed by scanner noise. The resolution is then between 0.1 and 1 µm/s with 1 Hz spectral resolution.

[4] The typical value refers to the center of the operating frequency range.

[5] Conditions: sinusoidal vibration, f = 1 kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[6] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote[5]).

[7] Harmonic distortions are defined 70% of full scale for the wanted signal. In each case the bandwidth is specified, in which the distortion can occur.

[8] The maximum amplitude of the distortion refers to the full scale. An exception of which is a single peak, generated by the optical sensor, in the frequency region 20...25kHz, whose amplitude depends on the stand-off distance.

Auxiliary Decoder VD-05 (Velocity Decoder, only PSV-400-M2-20)

Measurement range	100	500	$\frac{mm}{s}/V$
Full scale (peak)			
Nominal	0.5	2.5	m/s
Maximum	0.6	3	m/s
Frequency range			m/s
f_{min}	0.5	0.5	Hz
f_{max}	10	10	MHz
Max. acceleration	320000	1600000	g
Frequency response[1]			
0.5 Hz...5 MHz	±0.2	±0.2	dB
5 MHz...10 MHz	±0.5	±0.5	dB
Resolution[2]	< 3	< 3	$\frac{\mu m}{s}/\sqrt{Hz}$
Pulse response			
Rise time $t_{10\text{-}90}$	< 25	< 25	ns
Signal delay t_D	< 100	< 100	ns
Overshoot	< 20	< 20	%
Calibration error[3]			
T_a = (25 ±3)°C (T_a = (77 ±5)°F)	±2	±2	%
Linearity error[4]	2	2	%
Harmonic distortions	< –35	< –35	dBc
Spurious signals (non-harmonic)[5]	< –80	< –80	dBFS

[1] The frequency response defines the frequency-dependent amplitude error, referred to the reference frequency of 1kHz.

[2] The noise-limited resolution is defined as the signal amplitude (rms) at which the signal-to-noise ratio is 0dB with 1Hz spectral resolution, measured on 3M ScotchliteTape® (reflective film). The attainable resolution is frequency-dependent. The typical value refers to the center of the operating frequency range.

[3] Conditions: sinusoidal vibration, f = 100kHz, amplitude 70% of full scale range, load resistance ≥ 1 MΩ

[4] The linearity error is defined as the amplitude-dependent, relative deviation of the scaling factor, referred to the scaling factor under calibration conditions (refer to footnote[5]).

[5] The maximum amplitude of the distortion refers to the full scale. The only exception to this is an individual peak generated by the optical signal in the frequency range 5...10MHz, which can attain an amplitude of up to –60dBFS.

Auxiliary Decoder DD-300 (Displacement Decoder, only PSV-400-M2-20)

Measurement range:	±75 nm	
Frequency range:	30 kHz…24 MHz (-3dB)	
Noise-limited resolution:	< 0.02 $pm/\sqrt{Hz}$ at 100% reflectivity < 0.05 $pm/\sqrt{Hz}$ when measuring on reflective film (corresponding to 0.25 nm (rms) at 20 MHz analysis bandwidth)	
Scaling factor:	50 nm/V at load resistance 50 Ω ±1% (25 nm/V at load resistance >10 kΩ)	
Output swing:	±1.5 V at load resistance 50 Ω (±3 V at load resistance >10 kΩ)	
Output impedance:	50 Ω	
Load resistance:	50 Ω ±1%[1]	
NF suppression:	Crossover frequency:	typ. 30 kHz (–3 dB)
	Frequency roll-off:	–12 dB/oct.
Pulse response:	Propagation delay t_D:	< 140 ns
	Rise time $t_{10\text{-}90}$:	< 25 ns
	Overshoot:	< 20%
Calibration error:	< ±5% (sinusoidal vibration, frequency 500 kHz, amplitude 50 nm, load resistance 50 Ω)	
Amplitude frequency response:	refer also to FIGURE 7.1	
	BNC jack AUXILIARY OUTPUT:	±1 dB (50 kHz…20 MHz)
	BNC jack AUXILIARY UNIVERSAL:	+0.5/–1 dB (50 kHz…2 MHz)
Linearity error:	<±2% to 60 nm Peak, refer to FIGURE 7.2	
Spurious signals (non-harmonic)[2]:	<100 µV (rms)	

[1] The specifications apply for a load resistance of 50 Ω.With frequencies of less than 5 MHz or if the pulse has a slow steep rising edge respectively, the outputs can also be terminated with high impedance. In this case the data given in brackets is for information purposes.

[2] Non-harmonic interference signals are independent of the wanted signal. When making measurements on mirror-like surfaces two more peaks in the frequency range from 8 MHz to 25 MHz with higher amplitudes can occur, whose frequencies depend on the optical sensor.

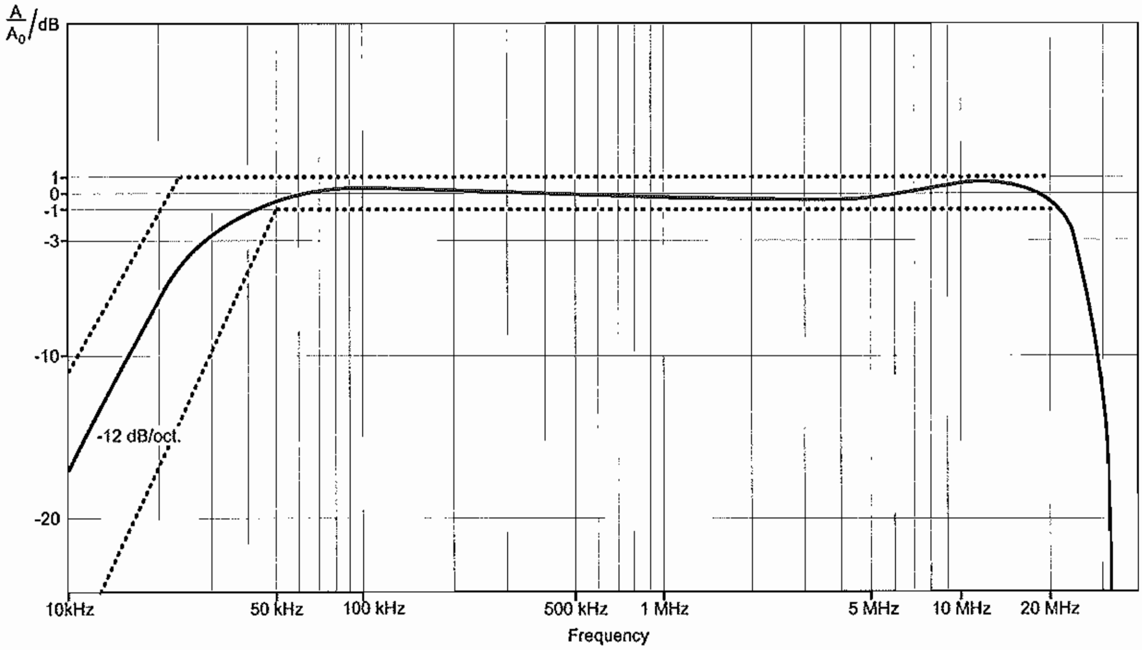

Figure 7.1: Typical amplitude frequency response with tolerance band

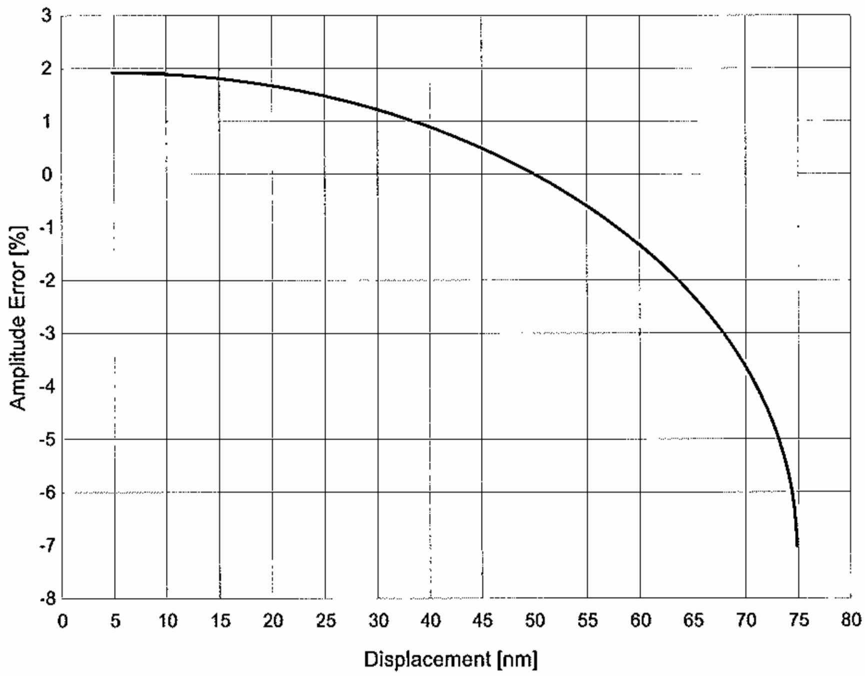

Figure 7.2: Typical linearity error of the DD-300

Harmonic Distortions

Vibration frequency	Vibration amplitude[1]	
	0...25 nm:	25...50 nm:
1 MHz	< −50 dBc	< −40 dBc
5 MHz	< −50 dBc	< −37 dBc
10 MHz	< −34 dBc	< −30 dBc

[1] Harmonic distortions are produced from multiples of vibration frequencies. They depend on the frequency and the amplitude of the wanted signal. The maximum amplitude in dBc corresponds to the amplitude of the base frequency.

7.2.5 Analog Low Pass and High Pass Filter

Low Pass Filter

For a typical amplitude and phase frequency response, refer to SECTION B.1

Filter type: Bessel 3rd order
Cutoff frequencies: 5 kHz, 20 kHz, 100 kHz (adjustable)
Frequency roll-off: −60 dB/dec = −18 dB/oct
Stop band attenuation: > 70 dB

High Pass Filter

For a typical amplitude and phase frequency response, refer to SECTION B.2

Filter type: Butterworth 4th order
Cutoff frequency: 100 Hz
Frequency roll-off: −80 dB/dec = −24 dB/oct
Stop band attenuation: > 70 dB

7.3 Junction Box PSV-E-401

7.3.1 General Data

Mains Connection

Mains voltage::	100...240 VAC ±10%, 50/60 Hz
Power consumption:	max. 100 VA
Fuses:	3.15 A/slow-blow
Safety class:	I (protective grounding)

Ambient Conditions

Operating temperature:	+5°C...+40°C (41°F...104°F)
Storage temperature:	−10°C...+65°C (14°F...149°F)
Relative humidity:	max. 80%, non-condensing

Housing

Dimensions:	450 mm x 360 mm x 135 mm (19", 84 HE/3 U)
Weight:	9 kg

7.3.2 Digital Interfaces

RS-232:	8 data bit, 1 stop bit, no parity; Transfer rate: 115200 Baud; RS-232 (X) cable to the controller: 2 x 9-pin Sub-D jack, null modem cable (cross-wired)
USB:	Universal Serial Bus Type B; Cable to the PC: 1 x USB Type A, 1 x USB Type B

7.3.3 Analog Signal Inputs and Outputs

VELO, REF1 (REF2 and REF3 only PSV-400-H4 and M4)

	PSV-400-H4/-B	PSV-400-M2/-M4	PSV-400-M2-20	
Input voltage range (adjustable in the software):	±100 mV...±31.6 V	±200 mV...±10 V	±200 mV...±10 V	
Input impedance:	1 MΩ parallel with 100 pF	1 MΩ parallel with 100 pF	50 Ω	1 MΩ parallel with 100 pF
Input coupling:	AC/DC, adjustable in the software AC −3 dB cutoff frequency: 3.4 Hz		DC	DC
Overvoltage protection:	±42 V (against damage)		$5\,V_{rms}$	±20 V
Operating modes: Initial state (adjustable in the software)	Single-ended Differential	Single-ended Differential	Single-ended -	

IEPE Mode (ICP®) REF1 (REF2 and REF3 only PSV-400-H4 and -M4):

Sensor supply: nom. 4 mA/24 V, IEPE compatible (ICP®)

Lower cutoff frequency: 0.02 Hz (−3 dB), with DC coupling of the REF inputs

Time constant: 10 s

Noise in the IEPE mode (ICP®) with PSV-400-H4 or -B:

Input voltage range	Frequency	Noise[1] (typ.)
±10 V	1 Hz	39.8 µV/√Hz (−88 dBV/√Hz)
	10 Hz	10.0 µV/√Hz (−100 dBV/√Hz)
	100 Hz	6.3 µV/√Hz (−104 dBV/√Hz)
	1 kHz	4.4 µV/√Hz (−107 dBV/√Hz)
	10 kHz	4.4 µV/√Hz (−107 dBV/√Hz)
±1 V	1 Hz	10 µV/√Hz (−100 dBV/√Hz)
	10 Hz	3.1 µV/√Hz (−110 dBV/√Hz)
	100 Hz	0.89 µV/√Hz (−121 dBV/√Hz)
	1 kHz	0.70 µV/√Hz (−123 dBV/√Hz)
	10 kHz	0.70 µV/√Hz (−123 dBV/√Hz)
±100 mV	1 Hz	17.7 µV/√Hz (−95 dBV/√Hz)
	10 Hz	2.8 µV/√Hz (−111 dBV/√Hz)
	100 Hz	0.56 µV/√Hz (−125 dBV/√Hz)
	1 kHz	0.31 µV/√Hz (−130 dBV/√Hz)
	10 kHz	0.31 µV/√Hz (−130 dBV/√Hz)

[1] The noise measurements were carried out with the ICP® sensor M352C65 connected.

TRIG IN

	PSV -400-H4/-M2/-M4/-B	PSV-400-M2-20
Compatibility:	TTL	TTL
Input voltage:	max. +5.5V	max. +7.0V

GATE IN

	PSV-400-H4/-M2/-M4/-B	PSV-400-M2-20
Compatibility:	TTL	-
Input voltage:	max. +7.0V	-

AUX IN

	PSV-400-H4/-M2/-M4/-B	PSV-400-M2-20
Compatibility:	TTL	TTL
Input voltage:	max. +7.0V	max. +7.0V

SIGNAL 1, SIGNAL 2, SIGNAL 3 and SIGNAL 4

	PSV-400-H4/-M2/-M4/-B	PSV-400-M2-20
Output voltage swing:	max. ±5.5V	max. ±3V
Output current:	max. ±5mA	max. ±50mA
Output impedance:	50Ω ±10%	50Ω ±10%
Short-circuit protection:	Permanently short-circuit proof	

SYNC

	PSV-400-H4/-M2/-M4/-B	PSV-400-M2-20
Compatibility:	TTL	TTL
Output voltage HIGH:	min. 4.35V (I_{out} = 3.5mA)	min. 3.8V (I_{out} = 8mA)
Output voltage LOW:	max. 0.4V (I_{out} = 5mA)	max. 0.4V (I_{out} = 8mA)

AUX OUT

	PSV-400-H4/-M2/-M4/-B	PSV-400-M2-20
Compatibility:	TTL	TTL
Output voltage HIGH:	min. 2.4V (I_{out} = 15mA)	min. 2.4V (I_{out} = 15mA)
Output voltage LOW:	max. 0.5V (I_{out} = 64mA)	max. 0.5V (I_{out} = 64mA)

S-VIDEO OUT

Video signal (Y/C:)	1V_{p-p} /75Ω

7.4 Junction Box PSV-E-408 (optional, only PSV-400-H4)

7.4.1 General Data

Ambient Conditions

Operating temperature:	+5°C...+40°C (41°F...104°F)
Storage temperature:	−10°C...+65°C (14°F...149°F)
Relative humidity:	max. 80%, non-condensing

Housing

Dimensions:	482m x 303mm x 23mm
Weight:	1.5kg

7.4.2 Analog Signal Inputs

REF 21, REF 22, REF 23 and REF 24

Input voltage range:	±100mV...±31.6V, adjustable in the software
Input impedance:	1MΩ parallel with 100pF
Input coupling:	AC/DC, adjustable in the software AC −3dB cutoff frequency: 3.4Hz
Overvoltage protection:	±42V (against damage)
Operating modes:	Single-ended (initial state) Differential (adjustable in the software)

IEPE Mode (ICP®) REF 21, REF 22, REF 23 and REF 24:

Sensor supply:	nom. 4mA/24V, IEPE compatible (ICP®)
Lower cutoff frequency:	0.02Hz (−3dB), with DC coupling of the REF inputs
Time constant:	10s

Noise in the IEPE mode (ICP®):

Input voltage range	Frequency	Noise[1] (typ.)
±10V	1 Hz	39.8 µV/√Hz (−88 dBV/√Hz)
	10 Hz	10.0 µV/√Hz (−100 dBV/√Hz)
	100 Hz	6.3 µV/√Hz (−104 dBV/√Hz)
	1 kHz	4.4 µV/√Hz (−107 dBV/√Hz)
	10 kHz	4.4 µV/√Hz (−107 dBV/√Hz)

Input voltage range	Frequency	Noise[1] (typ.)
±1 V	1 Hz	$10\,\mu V/\sqrt{Hz}$ ($-100\,dBV/\sqrt{Hz}$)
	10 Hz	$3.1\,\mu V/\sqrt{Hz}$ ($-110\,dBV/\sqrt{Hz}$)
	100 Hz	$0.89\,\mu V/\sqrt{Hz}$ ($-121\,dBV/\sqrt{Hz}$)
	1 kHz	$0.70\,\mu V/\sqrt{Hz}$ ($-123\,dBV/\sqrt{Hz}$)
	10 kHz	$0.70\,\mu V/\sqrt{Hz}$ ($-123\,dBV/\sqrt{Hz}$)
±100 mV	1 Hz	$17.7\,\mu V/\sqrt{Hz}$ ($-95\,dBV/\sqrt{Hz}$)
	10 Hz	$2.8\,\mu V/\sqrt{Hz}$ ($-111\,dBV/\sqrt{Hz}$)
	100 Hz	$0.56\,\mu V/\sqrt{Hz}$ ($-125\,dBV/\sqrt{Hz}$)
	1 kHz	$0.31\,\mu V/\sqrt{Hz}$ ($-130\,dBV/\sqrt{Hz}$)
	10 kHz	$0.31\,\mu V/\sqrt{Hz}$ ($-130\,dBV/\sqrt{Hz}$)

[1] The noise measurements were carried out with the ICP® sensor M352C65 connected.

7.5 PC PSV-W-401

7.5.1 General Data

Mains Connection

Mains voltage::	100...240 VAC ±10%, 50/60 Hz
Power consumption:	max. 350 VA
Safety class:	I (protective grounding)

Ambient Conditions

Operating temperature:	+5°C...+40°C (41°F...104°F)
Storage temperature:	−10°C...+65°C (14°F...149°F)
Relative humidity:	max. 80 %, non-condensing

Housing

Dimensions:	450 mm x 550 mm x 190 mm (19", 84 HE/4 U)
Weight:	18 kg

7.5.2 PC Configuration

Industrial PC

Processor:	min. AMD Athlon™ XP3000+; 2.6 GHz; 1 GByte RAM
Hard disk drive (HDD):	> 120 GB
Operating system:	Microsoft® Windows® XP or 2000
Network connector:	Ethernet
DVD recorder:	Refer to manual of the manufacturer

7.5.3 Data Acquisition

PSV model	PSV-400-H4 High frequency model 4 (8) channels	PSV-400-B Basic model
Data acquisition board	PCI-4462 (+PCI-4462)[1]	PCI-4461
Input channels (simultaneous)	4 (8)	2
Resolution	24 bit	24 bit
Maximum bandwidth	80 kHz	40 kHz
Internal function generator	PCI-6711	(integrated)
Output channels	4	(1)
Resolution	12 bit	(24 bit)
Maximum bandwidth	80 kHz	(20 kHz)

[1] The designations in brackets are available as an option.

PSV model	PSV-400-M2 High frequency model 2 channels	PSV-400-M4 High frequency model 4 channels
Data acquisition board	PCI-6111	PCI-6110
Input channels (simultaneous)	2	4
Resolution	12 ... 16 bit effectively (depending on the bandwidth)	12 ... 16 bit effectively (depending on the bandwidth)
Maximum bandwidth	1 MHz (2 MHz)[1]	1 MHz (2 MHz)
Internal function generator	integrated	integrated
Output channels	1	1
Resolution	16 bit	16 bit
Maximum bandwidth	500 kHz	500 kHz

[1] The designations in brackets are available as an option

PSV model	PSV-400-M2-20 High frequency model 2 channels (max. 20 MHz)
Data acquisition board	MI.3025
Input channels (simultaneous)	2
Resolution	12 bit
Maximum bandwidth	40 MHz
Internal function generator	MI.6030
Output channels	1
Resolution	14 bit
Maximum bandwidth	40 MHz

You will find detailed information in the manual of the data acquisition board or the generator board respectively which is installed on the PC.

7.6 Scanning Head PSV-I-400

7.6.1 General Data

Laser

Laser type::	Helium neon
Wavelength:	633 nm
Cavity length:	204 mm ±1 mm
Laser class:	2
Laser power:	< 1 mW

Electrical Data

Power consumption::	approx. 25 W (average value)
Carrier frequency:	40 MHz

Ambient Conditions

Operating temperature:	+5°C ... +40°C (41°F ... 104°F)
Storage temperature:	−10°C ... +65°C (14°F ... 149°F)
Relative humidity:	max. 80 %, non-condensing

Housing

Dimensions:	Refer to FIGURE 7.3
Weight:	7 kg

Dimensions

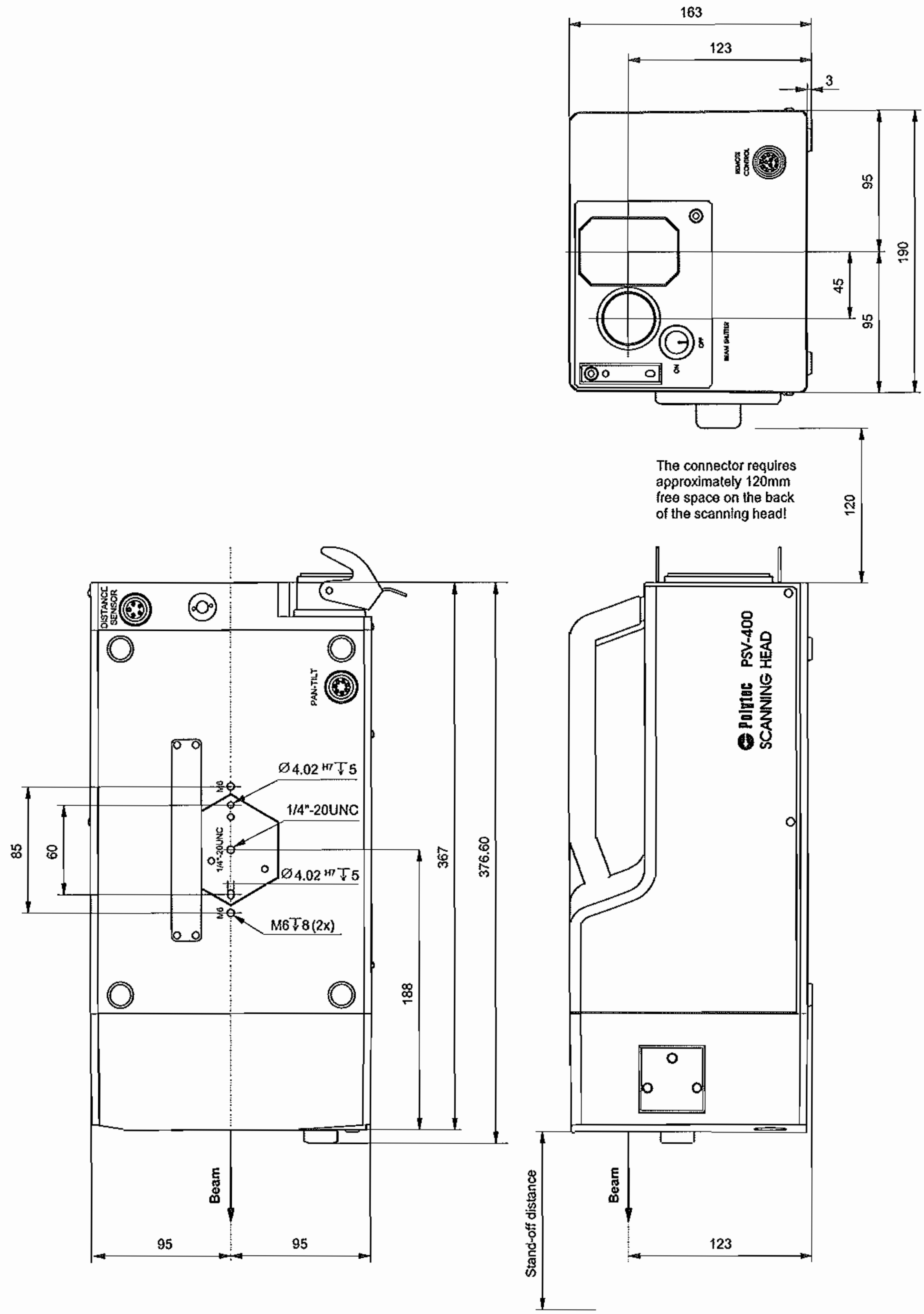

Figure 7.3: Views of the scanning head PSV-I-400 (Dimensions not specified are given in mm.)

7.6.2 Optics

Front lens model[1]		Long Range (LR)	Mid Range (MR)
Focal length	[mm]	100	60
Minimum stand-off distance	[mm]	350	40
Aperture diameter ($1/e^2$)	[mm]	10...11	2...6.6
Spot diameter (typ.)	[µm]		
@ 100 mm		-	31
@ 200 mm		-	41
@ 500 mm		33	73
@ 1000 mm		74	132
@ 2000 mm		147	255
@ 3000 mm		222	376
@ 5000 mm		368	624
@ each additional meter plus		74	126
Visibility maxima[2]		99 mm + (n · l); n = 0, 1, 2, ...; l = 204 mm ±1 mm	

[1] A label shows the front lens models which is fitted. The label for the front lens model is affixed on the bottom side of the scanning head (refer to FIGURE 7.4)

[2] Measured from the front panel of the scanning head (refer to FIGURE 7.3)

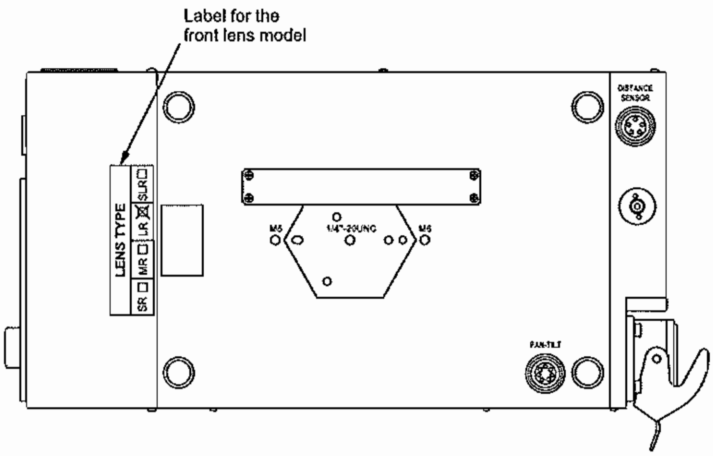

Figure 7.4: Position of the label for the front lens model

Table of the Visibility Maxima

Visibility Maxima (in mm) for l = 204mm					
99	1731	3363	4995	6627	8259
303	1935	3567	5199	6831	8463
507	2139	3771	5403	7035	8667
711	2343	3975	5607	7239	8871
915	2547	4179	5811	7443	9075
1119	2751	4383	6015	7647	9279
1323	2955	4587	6219	7851	9483
1527	3159	4791	6423	8055	...

7.6.3 Scanner

Type:	Servo-controlled galvo motor
Maximum deflection:	Horizontal: ±20° Vertical: ±20°
Angular resolution:	< 0.002°
Point stability:	< 0.01°/hour (after warm-up)

7.6.4 Video Camera

Video system:	CCIR/PAL	
Sensor:	Color CCD 1/4", 752x582 pixel	
Signal-to-noise ratio:	> 50dB	
Zoom:	72 x (4x digital zoom)	
Lens:	F 1,4 / f = 4,1...73mm, auto focus, auto iris 18-fold motor-driven zoom	
Angle of view (horizontal):	@ wide end:	approx. 48°
	@ max. tele end:	approx. 2.7°
Minimum stand-off distance:	@ wide end:	10mm
	@ max. tele end:	800mm
Minimum illumination:	3 Lux	

7.7 System Cabinet PSV-A-010

Housing

Dimensions:	600m x 900mm x 750mm
Weight:	102kg (including all instruments and cables, without scanning head and monitor)

7.8 Motorized Pan-Tilt Stage PSV-A-T11 (optional)

7.8.1 General Data

Mains Connection

Mains voltage:	115/230VAC, 50/60Hz, adjustable on the connection box
Power consumption:	approx. 30W (temporary)
Safety class:	I (protective grounding)

Ambient Conditions

Operating temperature:	−20°C...+50°C (-4°F...122°F)
Relative humidity:	max. 95%, non-condensing

Housing

Dimensions:	Top mount: 276mm x 149mm x 286mm
Weight:	12kg

7.8.2 Movement

Maximum angle of rotation:	Pan (horizontal):	±90°
	Tilt (vertical):	±84° (limited by limit switch)
Backlash:	±0.5° (testing moment 10Nm)	
Rotation velocity:	Horizontal:	6°/sec.
	Vertical:	5°/sec.
Max. load:	18kg	

Appendix A: Optional Accessory for the Scanning Head PSV-I-400

A.1 Scanning Head with Geometry Scan Unit PSV-A-420

A.1.1 Safety Information

Before using the scanning head with scan unit, please pay also attention to the advice on laser safety and electrical safety in CHAPTER 1.

Laser warning labels

The laser warning labels for the scanning head with geometry scan unit are shown in FIGURE A.1. In the countries of the European Union (EU), label **2** is affixed in the language of the customer's country (refer to the right).

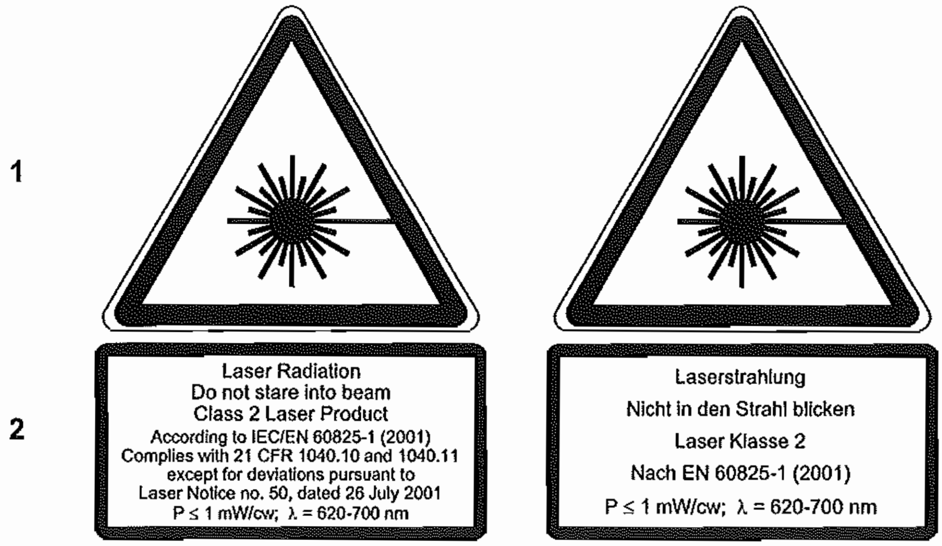

Figure A.1: laser warning labels for the scanning head with geometry scan unit

Position of the laser warning labels

The position of the laser warning labels on the scanning head with geometry scan unit is shown in FIGURE A.2.

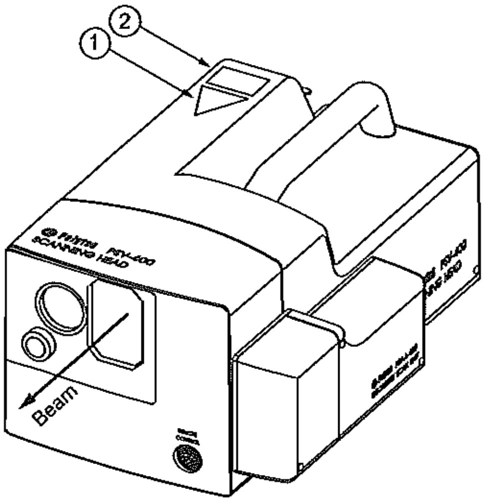

Figure A.2: Position of the laser warning labels on the scanning head with geometry scan unit

A.1.2 Introduction

With the aid of the geometry of the geometry scan unit you can determine exactly the distance to the object under investigation. If you want to make a geometric scan, the vibrometer laser is switched to the geometry laser and the position of the object under investigation will be determined. The geometry scan unit is shown in FIGURE A.3. In case of a signal overrange you can reduce the laser power via a filter. This filter is only controlled via the PSV software.

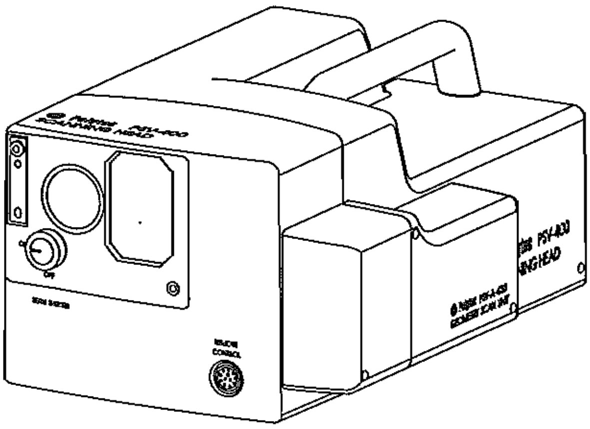

Figure A.3: Scanning head with geometry scan unit PSV-A-420

A.1.3 Control Elements

The control elements of the scanning head with geometry scan unit are shown in FIGURE A.4.

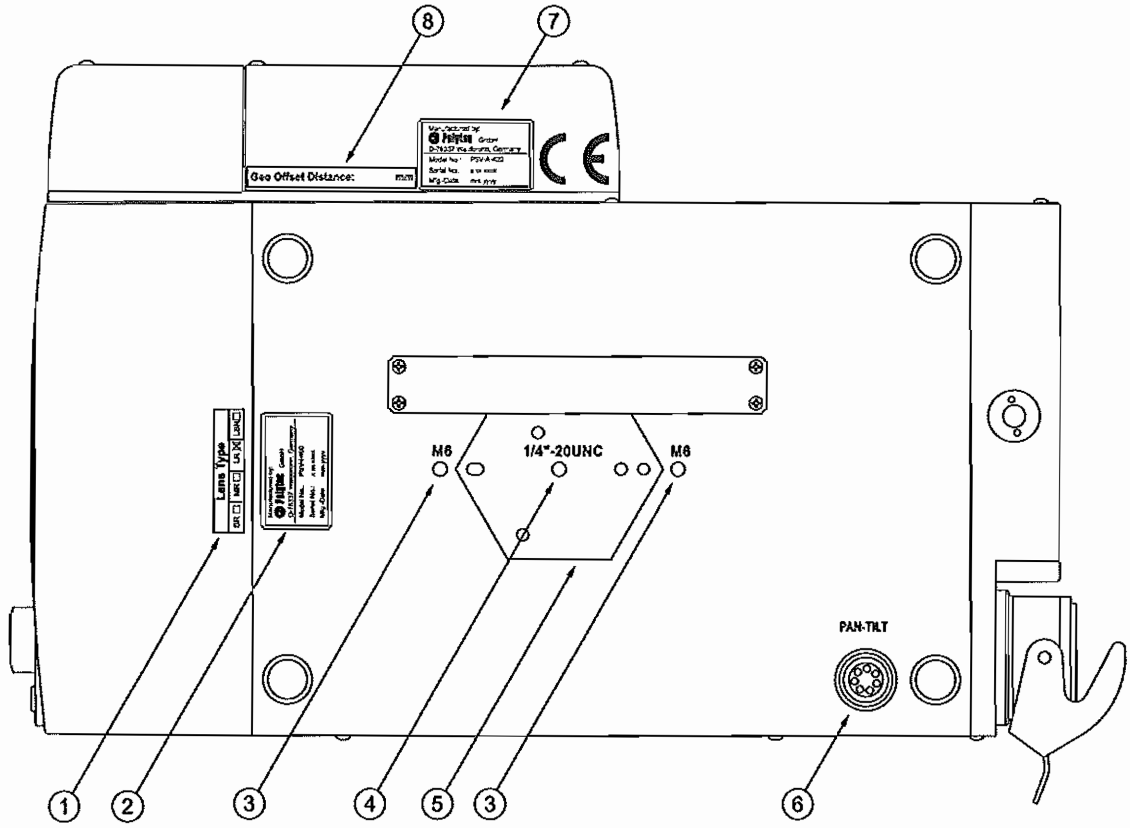

Figure A.4: Bottom view of the scanning head with geometry scan unit

1 **Label for the front lens model**

On this label, it is marked which front lens model is installed.

2 **Identification label**

On the identification label you will find, among other things, the serial number of the scanning head.

3 Mounting thread **M6**

With the two mounting threads the scanning head can be assembled on an adapter plate. You will find the dimensions of the mounting threads in the technical drawing in 7.6.

> **NOTE !**
>
> The mounting screws of the scanning head have to be tighten only with maximal 1,5 Nm otherwise the laser beam interference of the scanning head with the geometry scan unit can be disturbed!

4 Mounting thread **1/4"-20UNC**

Using the mounting thread, the scanning head can be mounted on stable camera tripods with thread basing on inch-system.

5 Mounting thread for hexagonal **quick release plate**

Using these mounting threads, the hexagonal quick release plate can be mounted on the scanning head, e.g. for mounting the scanning head on a tripod with fluid stage.

6 **PAN-TILT** connector for the optional pan-tilt stage (7-pin circular jack)

Connector for the connecting cable to the optional pan-tilt stage PSV-A-T11 to control the pan-tilt stage via the software

7 **Identification label**

On the identification label you will find, among other things, the serial number of the instrument

8 **Label for geo offset distance**

On the label the difference between the theoretic and real beam path in the scanning head is entered. The value is in the area of max. ±3mm. You must enter this value in the PSV software under Offset Distance. See your software manual on this.

A.1.4 Functional Test

For an initial functional test of the scanning head with geometry scan unit, you proceed as follows:

1. First carry out a functional test with your PSV as described in SECTION 3.5.
2. Now make a distance measurement with the scanning head with scan unit, as described in your software manual.
3. Use a measuring tape to measure the stand-off distance (distance between scanning head and object, refer also to FIGURE 7.3) and compare it with the distance determined by the software.

If the functional test has been successful you can now make measurements with the PSV as described in CHAPTER 4, CHAPTER 5 and your software manual. Remember that the PSV reaches its optimal properties after a warm-up period of approx. 20 minutes.

If your PSV does not perform as described above, read through the information on fault diagnosis provided in CHAPTER 6, if necessary, contact your local Polytec representative.

A.1.5 Technical Specifications

General Data

Laser

Laser type:	Laser diode
Wavelength:	620...690 nm
Laser class:	2
Laser power:	< 1 mW
Accuracy of the measurement distance:	±2.5 mm
Max. distance between the focal points of the two laser beams:	<5 mm (2σ) It will not be necessarily measured in the focal points of the laser beams.

Ambient Conditions

Operating temperature:	+5°C...+40°C (41°F...104°F)
Storage temperature:	−10°C...+65°C (14°F...149°F)
Relative humidity:	max. 80 %, non-condensing

Housing

Dimensions:	Refer to FIGURE A.5
Weight:	7.6 kg

Dimensions

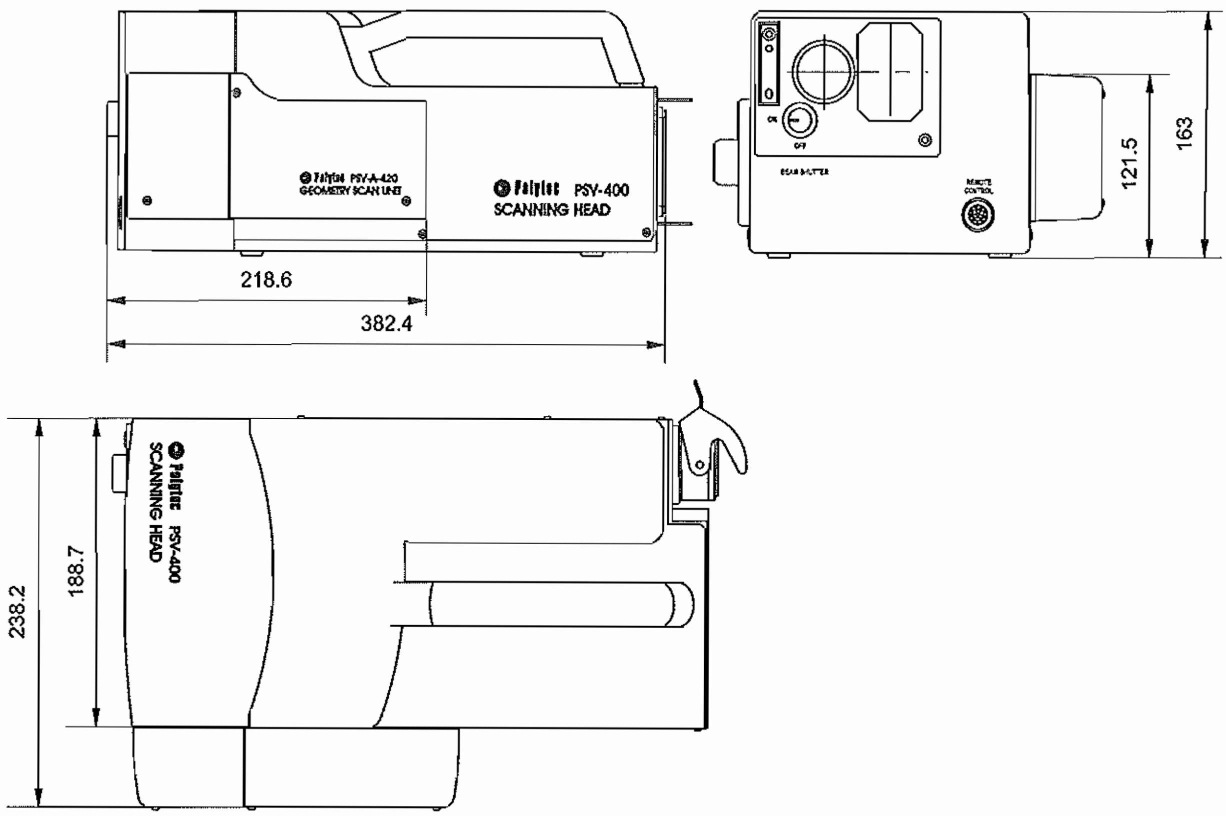

Figure A.5: Views of the scanning head with geometry scan unit (dimensions not specified are given in mm)

Filter (neutral filter)

The intensity of the laser beam is reduced to 1% by switching on the filter of the geometry scan unit. The filter is required in the case of the signal overrange on high-reflective surface.

> **NOTE !**
>
> Switching on the filter occurs **only** via the PSV software (refer to software manual)!

Laser power	(FILTER OFF):	<1 mW
	(FILTER ON):	approx. 10 µW

A.2 Close-up Unit PSV-A-410 with Appropriate Accessory

A.2.1 Close-up Unit PSV-A-410-97 or PSV-A-410-99

You can scan small objects at short distance using the close-up unit shown in FIGURE A.6. Thereby the beam path of the laser is overlaid to the video image to equalize the parallax error.

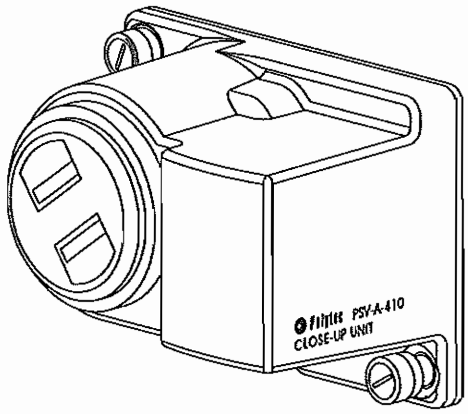

Figure A.6: Close-up unit PSV-A-410

To ensure a clearly visible laser spot on the video image, only small part of the laser light is used for the video camera. The size of the that part depends on the backscattering properties of the surface. Two models of the close-up unit are available which have different special coated beam splitters:

- **PSV-A-410-97** for mat surfaces (reduced the intensity of the laser light by 97%)
- **PSV-A-410-99** for highly reflective surfaces (reduced the intensity of the laser light by 99,8%)

Assembly of the Close-up Unit

For transportation the close-up unit is secured on the back with the a transparent perspex plate. For mounting the close-up unit, you proceed as follows:

1. Before mounting, undo the perspex plate and keep it in a safe place.
2. If required first screw the close-up unit lenses or the block filter (refer to SECTION A.2.2) to the camera aperture of the scanning head.
3. Fix the close-up unit on the front of the scanning head using the two knurled screws.

> ⚠ **CAUTION !**
>
> **Danger from mounting error!** - Pay attention to the correct fit of the precision pins and **only** hand-tighten the knurled screws!

NOTE !

Hand-tighten means: Tighten the screw firmly that it can not loosen itself. Do not use excessive force and avoid serious damage of thread.

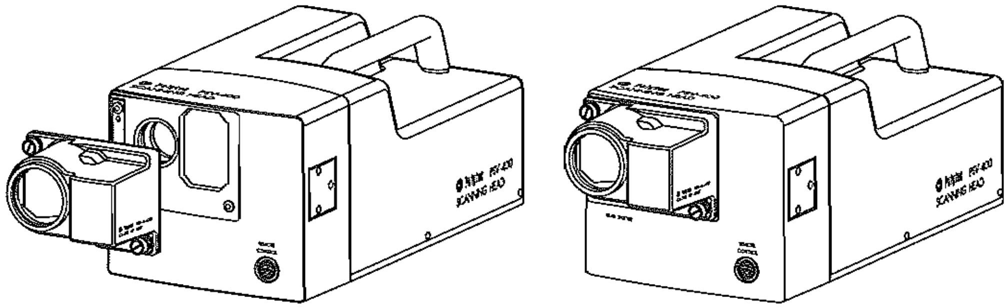

Figure A.7: Mounting the close-up-unit

Close-up Lenses

Together with the close-up unit set of close-up lenses with different focal distance (1, 2 and 4 diopters) is delivered. A maximum of two close-up lenses or one close-up lens and the block filter can be mounted. The close-up lenses are also screwed directly to the camera aperture of the scanning head before mounting the close-up unit. The stand-off distance and the scan fields of the close-up lenses and of combinations of the lenses are shown in TABLE A.1.

Table A.1: Stand-off distance and scan fields of the close-up lenses

Lens or combination	Stand-off distance[1]	Min. scan field (X x Y)	Nom. scan field[2] (X x Y)	Max. scan field (X x Y)	Focus point diameter[3] MR	LR
Diopters	mm	mm	mm	mm	µm	
2	320...450	5 x 4	20 x 16	70 x 55	67	25
2 + 1	250...350	4 x 3	16 x 8	60 x 45	56	-
4	200...260	3 x 2.4	12 x 10	50 x 40	49	-
4 + 1	175...215	2.5 x 2	10 x 8	45 x 34	45	-
4 + 2	152...175	2 x 1.6	8 x 6.4	40 x 30	41	-

[1] Measured from the front panel of the scanning head

[2] At 18 x optical zoom

[3] With front lens MR

Technical Specifications

Max. scan angle in x direction: ±5°

Max. scan angle in y direction: ±4°

Dimensions: 124mm x 90mm x 75mm and FIGURE A.8

Weight: 0.35kg

Dimensions

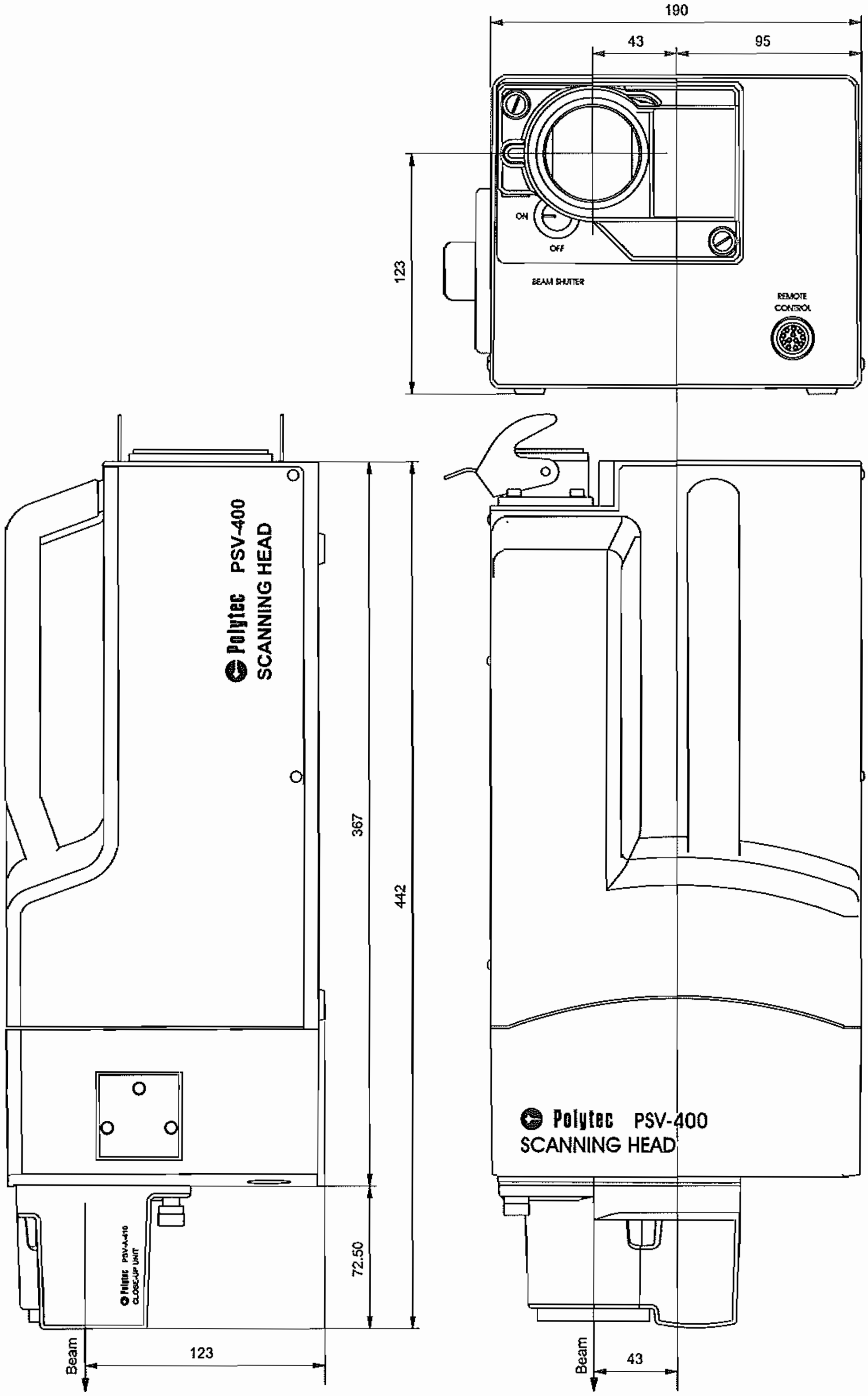

Figure A.8: View of the scanning head with the close-up unit (Dimensions not specified are given in mm)

A.2.2 Block Filter PSV-A-HNeBF

If the intensity of the laser light is still too high the supplied helium neon block filter should be mounted additionally. The block filter is screwed directly to the camera aperture of the scanning head and reduces once more the intensity of the laser light back scattered to the video camera by 98%.

A.2.3 Micro Scan Lenses PSV-A-CL-xxx

By attaching the micro scan lenses, scan fields down to 1 mm x 1.2 mm are achieved at a fixed stand-off distance. The specialty of the micro scan lenses is that the laser beam nearly perpendicular meets the measurement surface as also shown in FIGURE A.9 for the PSV-A-CL-150. Without loss of signal quality, mirror like objects can be scanned up to a tilt of ±4°.

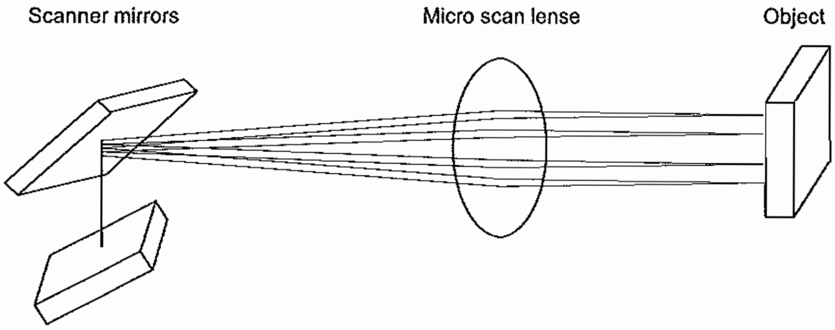

Figure A.9: Function principle of the micro scan lenses

Assembly

Undo the protective cap of the objective of the close-up unit and screw the micro scan lens onto the objective.

Technical Specifications

The stand-off distance and scan field of the different micro scan lenses are shown in TABLE A.2. The nominal scan field values are suitable for orientation. Stronger zoom is achieved by interpolation which might reduce the quality of the video image.

Table A.2: Stand-off distance and scan field of the micro scan lenses

Micro scan lens PSV-A-	Stand-off distance[1] mm	Min. scan field (X x Y) mm	Nom. scan field[2] (X x Y) mm	Max. scan field (X x Y) mm	Spot diameter[3] µm	Depth of field
CL-80	160	1.2 x 1.0	5 x 4	14 x 10	7	0.4
CL-150	230	1.8 x 1.3	7 x 5	23 x 17	13	1.3
CL-300	380	2.6 x 3.5	10 x 14	46 x 35	25	5.0

[1] Measured from the front panel of the scanning head

[2] At 18 x optical zoom

[3] With front lens MR

A.2.4 Fiber-Optic Ring Light PSV-A-RLight

To enhance the quality of the video image the optional fiber-optic ring-light can be mounted on the micro scan lenses PSV-A-CL-80 and PSV-A-CL-150.

Assembly

For mounting the ring-light, you proceed as follows:

1. Mount the ring light on the micro scan lens and hand-tighten the knurled screw.

> **NOTE !**
>
> Hand-tighten means: Tighten the screw firmly that it can not loosen itself. Do not use excessive force and avoid serious damage of thread.

2. Undo the protective cap from the another end of the fiber cable.

3. Insert the fiber cable into the ´Modulamp` receptacle of the light source and tighten the fiber optic positioning thumbscrew.

> **WARNING !**
>
> **Danger from high intense light!** - Never look directly at the ring light when the light source is switched on !

For more information above the light source, please refer to the user manual of the manufacturer.

A.3 Test Stand PSV-A-T18

You can adjust the stand-off distance of the mounted scanning head precisely using the test stand. The test stand is especially suitable for scanning very small parts with the close-up unit on the scanning head. The vertical and the horizontal test stand are shown in FIGURE A.10 and FIGURE A.11.

The test stand PSV-A-T18 is made up of:

- Motorized 3-stage telescope drive
- Adapter plate for the PSV-I-400 scanning head
- Drive control
- Hand set

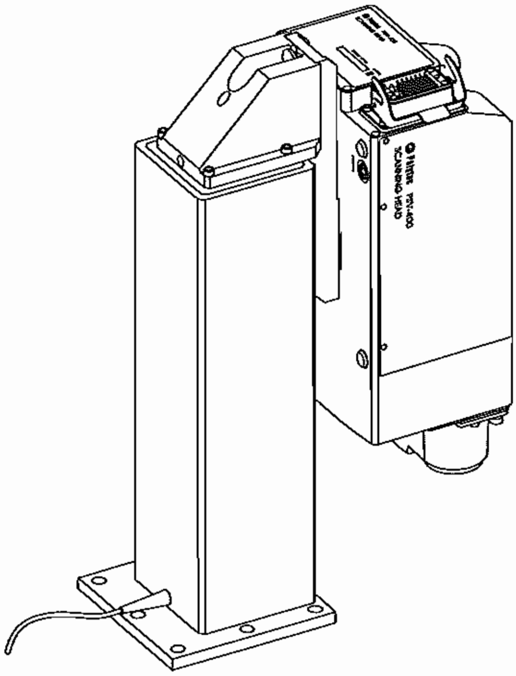

Figure A.10:Vertical test stand with scanning head and close-up unit mounted

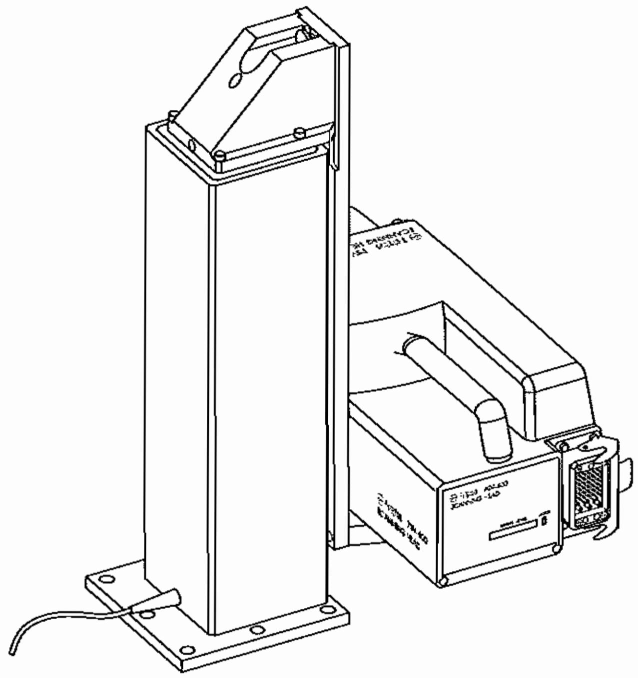

Figure A.11: Horizontal test stand with scanning head and close-up unit mounted

Assembly of the Vertical Test Stand

For mounting the scanning head at the telescope drive, you proceed as follows:

1. Fix the telescope drive at the measurement location using 7 screws of the assembly kit (refer to FIGURE A.12, picture 1).

   Use either the metric screws ***or*** *the separately packed screws with thread basing on inch-system (1/4-20x1/2" UNC).*

2. If applicable, undo the quick release hexagonal plate or the mounting plate for the pan-tilt stage from the scanning head.

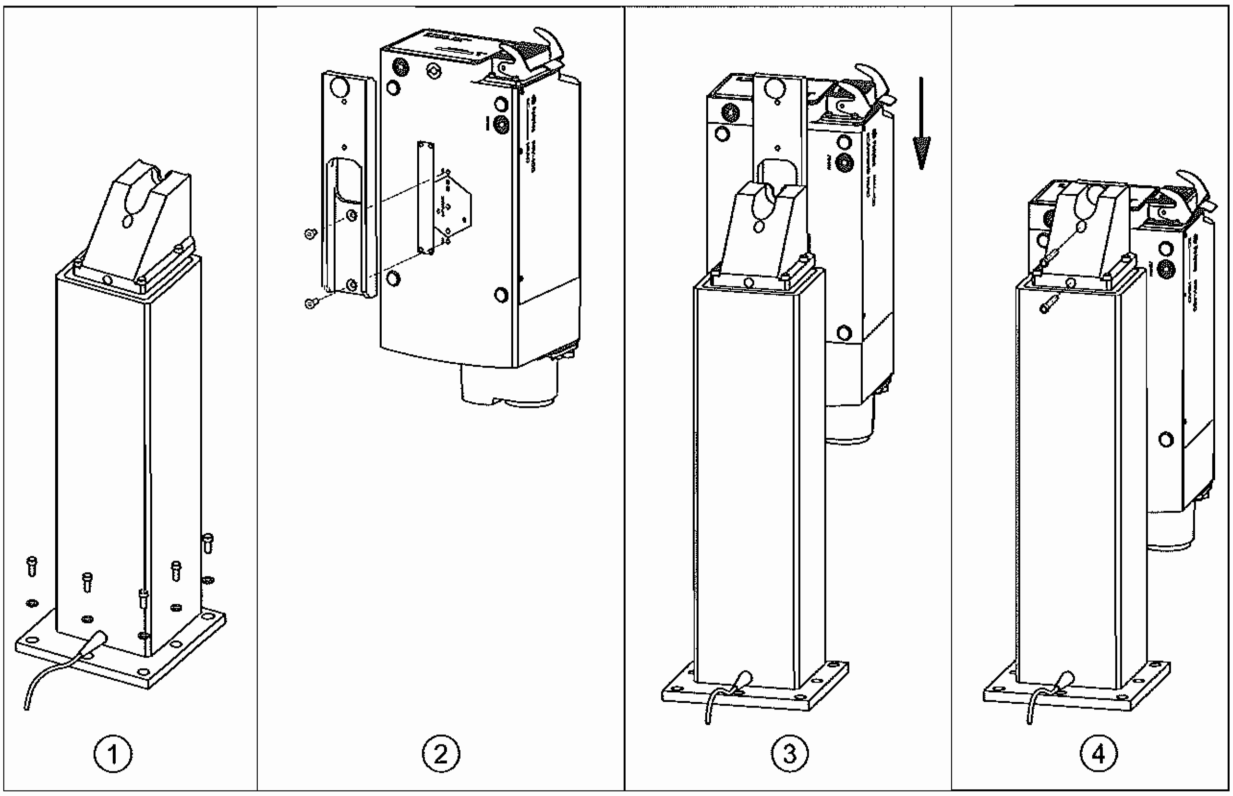

Figure A.12:Mounting the scanning head to the telescope drive of the vertical test stand

3. Attach the adapter plate on the underside of the scanning head as shown in FIGURE A.12, picture 2.

4. Hang up the scanning head with the adapter plate above at the telescope drive (refer to FIGURE A.12, picture 3).

5. Secure the scanning head by fixing the adapter plate to the telescope drive using 2 Allen screws (refer to FIGURE A.12, picture 4).

Assembly of the Horizontal Test Stand

For mounting the scanning head at the telescope drive, you proceed as follows (refer to FIGURE A.13):

1. Fix the telescope drive at the measurement location using 7 screws of the assembly kit.

   Use either the metric screws ***or*** *the separately packed screws with thread basing on inch-system (1/4-20x1/2" UNC).*

2. If applicable, undo the quick release hexagonal plate or the mounting plate for the pan-tilt stage from the scanning head.

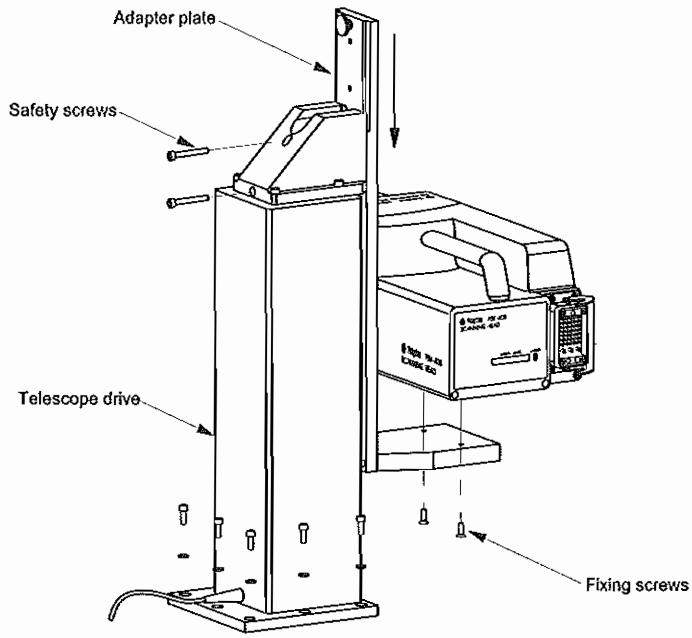

Figure A.13:Assembly of the horizontal test stand

3. Attach the adapter plate on the underside of the scanning head using the 2 fixing screws.

4. Hang up the scanning head with the adapter plate above the telescope drive.

5. Secure the scanning head by fixing the adapter plate to the telescope drive using 2 safety screws.

Cabling

For the electrical connection of the test stand, you proceed as follows:

1. Connect the cable of the telescope drive to the motor connection **3** of the drive control in FIGURE A.14.

2. Plug the hand set cable into the Sub-D jack **2** in FIGURE A.14.

3. Plug the mains cable into connection 1 of the drive control and into an earthed socket.

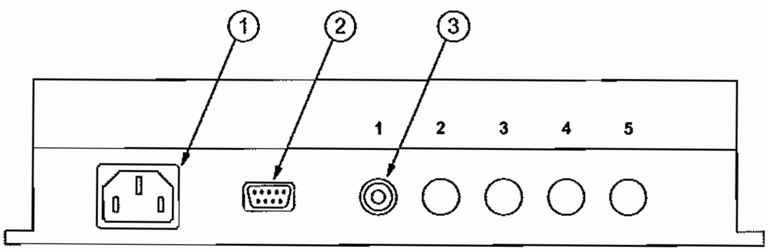

Figure A.14:Connection of the drive control

4. To move the scanning head upstairs, press the arrow key ↑ on the hand set. Move the scanning head downstairs by pressing the arrow key ↓ on the hand set.

5. If you press the arrow key for more the approximately 2 seconds, the motor switches over to fast mode. After approximately 3 seconds the motor reaches its maximum velocity. For fine positioning, the arrow key can be repeatedly pressed briefly.

Technical Specifications

Drive Control

Mains voltage:	240V/50Hz **or** 115V/50-60Hz
Output power:	24V DC/5A
Protection rating:	IP66
Operating temperature:	0°C...+40°C (32°F...104°F)
Dimensions:	130m x 80mm x 360mm
Weight:	2.9kg

Telescope Drive

Protection rating:	IP30
Operating temperature:	+10°C...+40°C (50°F...104°F)
Operating time - intermittent:	max. 1min. (9min. break)
Operating time - continuous:	max. 2.5min.
Velocity stages:	3
Max. velocity:	5.5mm/s
Min. travel:	approx. 0.1mm
Max. travel:	300mm
Dimensions:	180mm x 180mm x 590mm (+ 300mm throw), refer also to FIGURE A.15 and FIGURE A.16
Weight:	13.8kg vertical test stand 16kg horizontal test stand

Dimensions of the Vertical Test Stand

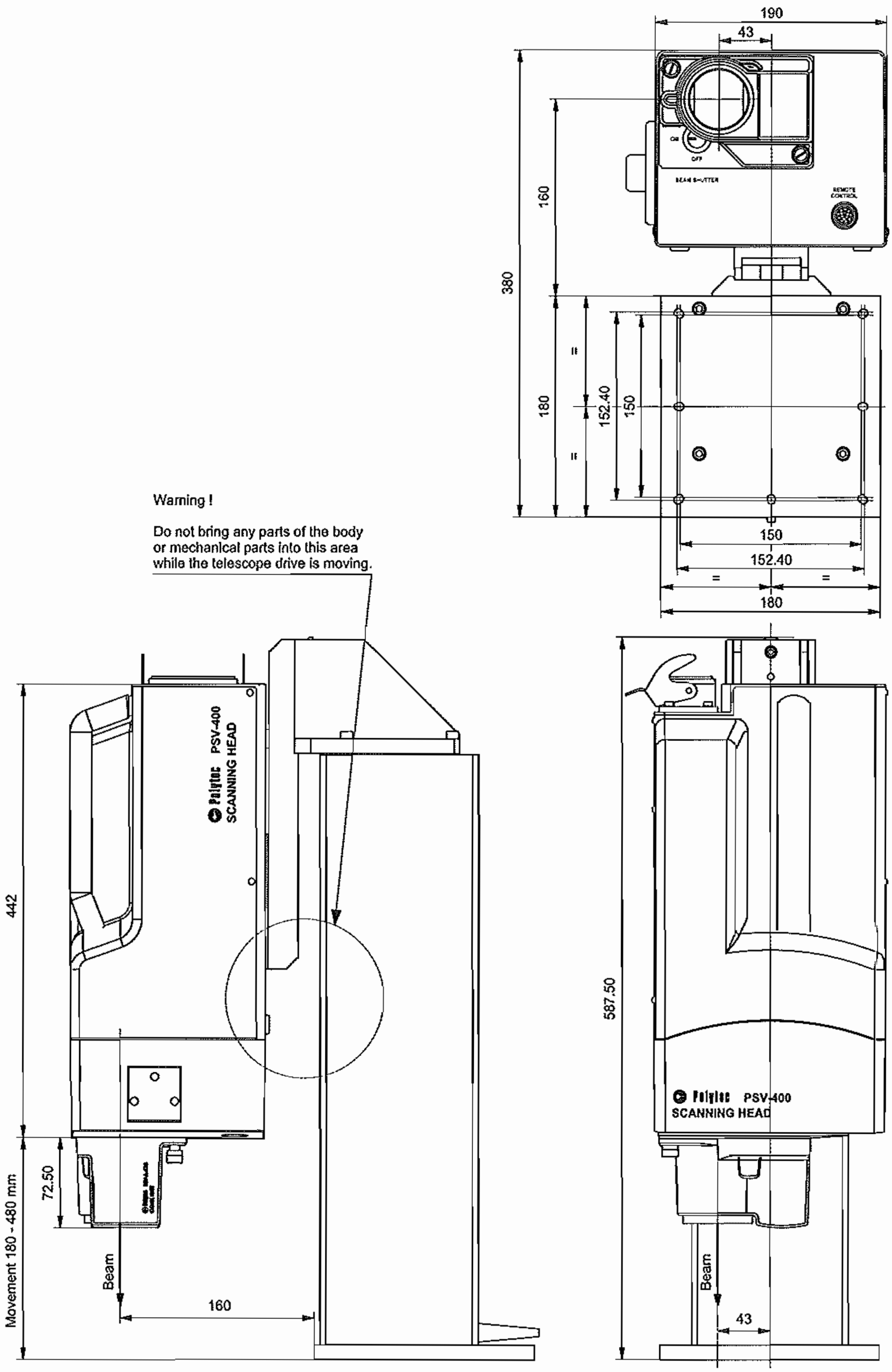

Figure A.15:View of the vertical test stand with scanning head (Dimensions not specified are given in mm)

Dimensions of the Horizontal Test Stand

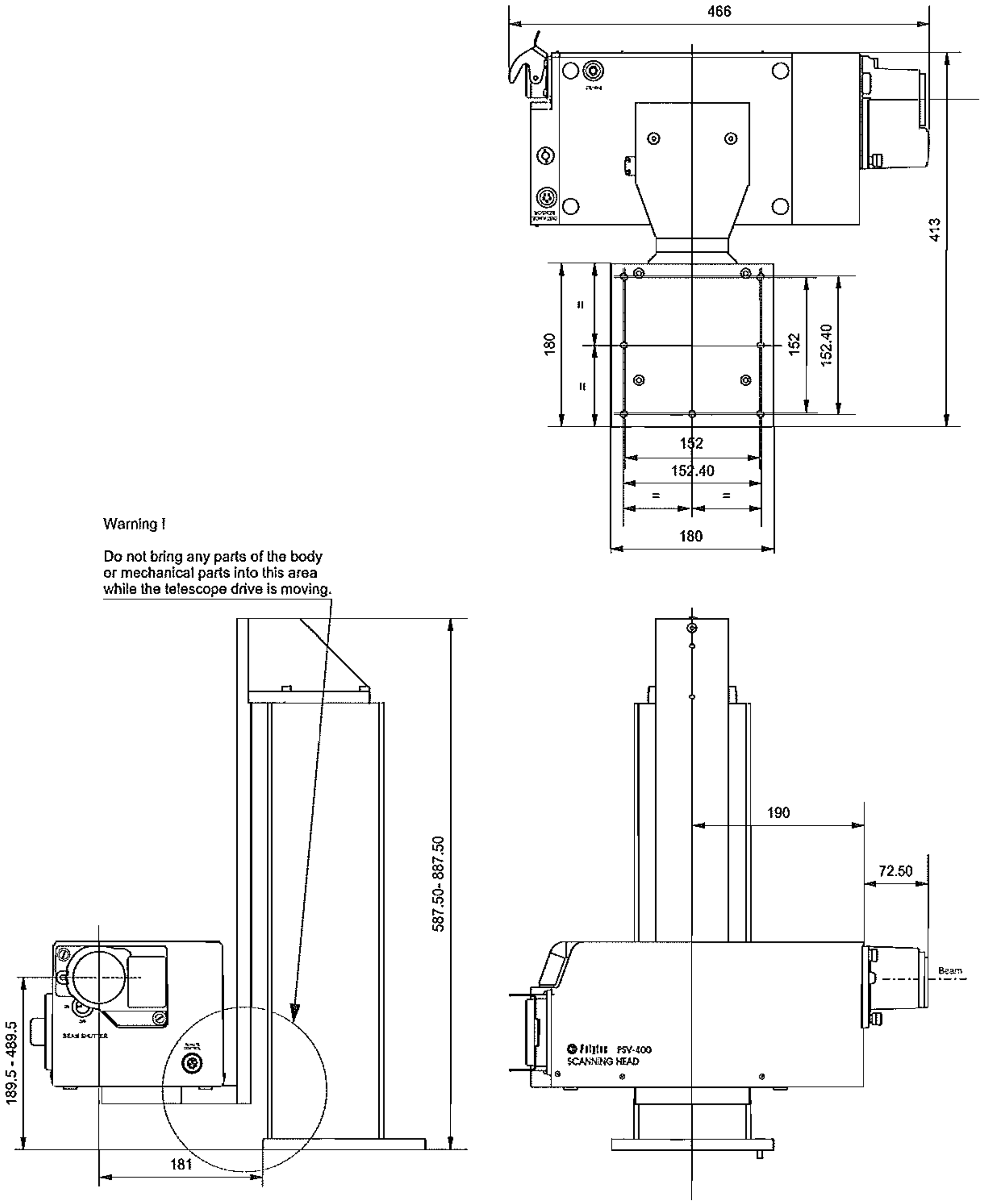

Figure A.16:View of the horizontal test stand with scanning head (Dimensions not specified are given in mm)

Appendix B: Basics of the Measurement Procedure

B.1 Theory of Interferometric Velocity and Displacement Measurement

Optical interference can be observed when two coherent light beams are made coincide. The resulting intensity e.g. on a photo detector varies with the phase difference φ between the two beams according to the equation

$$I(\varphi) = \frac{I_{max}}{2} \cdot (1 + \cos\varphi) \qquad \text{Equation B.1}$$

The phase difference φ is a function of the optical path difference L between the two beams according to

$$\varphi = 2\pi \cdot \frac{L}{\lambda} \qquad \text{Equation B.2}$$

where λ is the laser wavelength.

If one of the two beams is scattered back from a moving object (the object beam), the path difference becomes a function of time $L = L(t)$. The interference fringe pattern moves on the detector and the displacement of the object can be determined using directionally sensitive counting of the passing fringe pattern.

The velocity component in the direction of the object beam is a function of the path difference L according to

$$\frac{dL(t)}{dt} = v(t) \cdot 2 \qquad \text{Equation B.3}$$

For a constant movement v applies

$$\left|\frac{dL(t)}{dt}\right| = \frac{\lambda}{2\pi} \cdot \left|\frac{d\varphi}{dt}\right| = f_D \cdot \lambda = |v| \cdot 2 \qquad \text{Equation B.4}$$

with

$$f_D = 2 \cdot \frac{|v|}{\lambda} \qquad \text{Equation B.5}$$

Thus a movement of the object causes a frequency shift at the object beam which is called Doppler shift f_D. Superimposing object beam and internal reference beam, i.e. two electromagnetic waves with slightly different frequencies, generates a beat frequency at the detector which is equal to the Doppler shift. The equation B.5 to determine the velocity is, however independent of its sign. The direction of the velocity can be determined by introducing an additional fixed frequency shift f_B in the interferometer to which the Doppler shift is added with the correct sign.

Thus the resulting frequency at the detector f_{mod} is given by

$$f_{mod} = f_B + 2 \cdot \frac{v}{\lambda} \qquad \text{Equation B.6}$$

Interferometers of this type which are directionally sensitive are described as heterodyne.

B.2 Optical Configuration in the PSV-I-400 Scanning Head

In Polytec's vibrometers, the velocity and displacement measurement is carried out using a modified Mach-Zehnder interferometer.

The optical configuration of the scanning head is shown in FIGURE B.1.

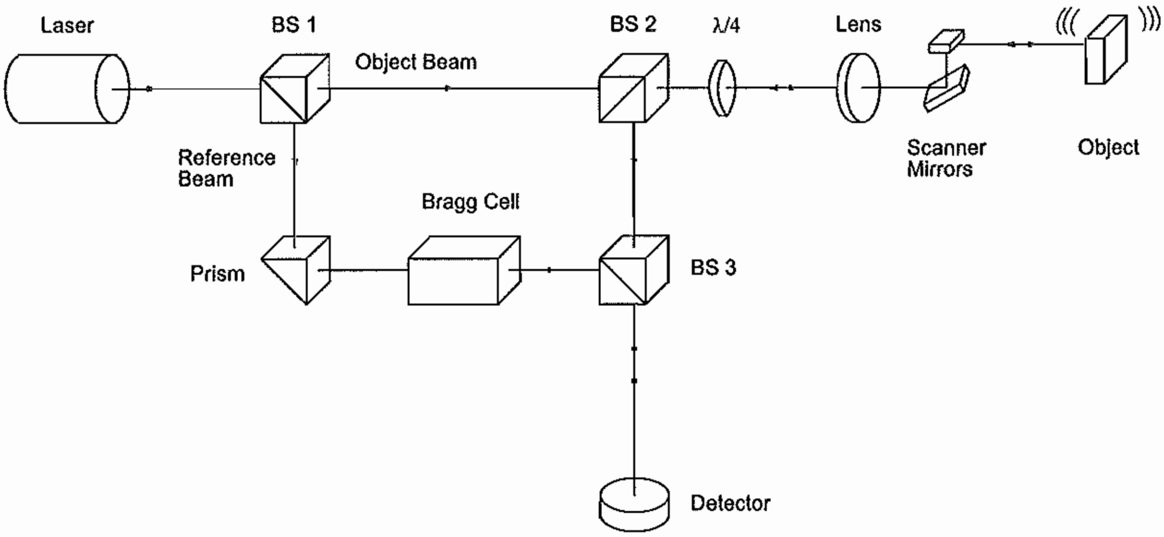

Figure B.1: Optical configuration in the scanning head

The light source is a helium neon laser which provides a linear polarized beam. The polarized beam splitter BS1 splits the beam into the object beam and the reference beam.

The object beam passes through the polarizing beam splitter BS2 as well as a λ/4 plate, is then focused by the lens on the objects and scattered back from there. The polarizing beam splitter BS2 then functions as an optical directional coupler together with the λ/4 plate, and deflects the object beam to the beam splitter BS3. The interference signal occur out of the optical path difference between reference and laser beam. The distance to the object goes into the optical path difference with a factor of 2. Optional the objective displays the object at the camera. If the spot diameter on the object is minimal, the video image is sharply focused.

The Bragg cell in the reference arm of the interferometer generates the additional frequency offset to determine the sign of the velocity.

The resulting interference signal of the object beam and the reference beam is converted into an electrical sign in the photo detector and subsequently decoded in the controller.

Appendix C: Filter Diagrams of the OFV-5000 Controller

C.1 Low Pass Filter with 3rd Order Bessel Characteristics

The frequency is normalized to the cutoff frequency f_c.

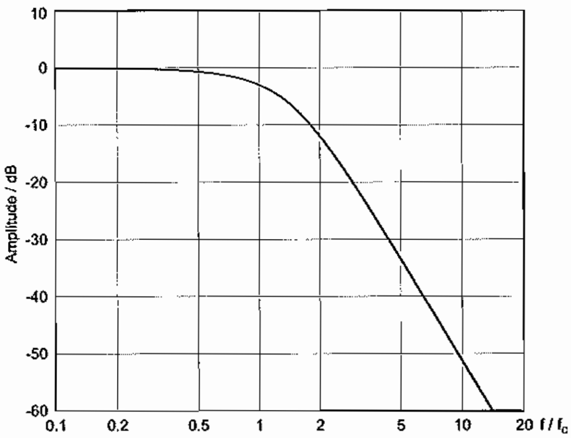

Figure C.1: Amplitude frequency response of a 3rd order Bessel low pass filter

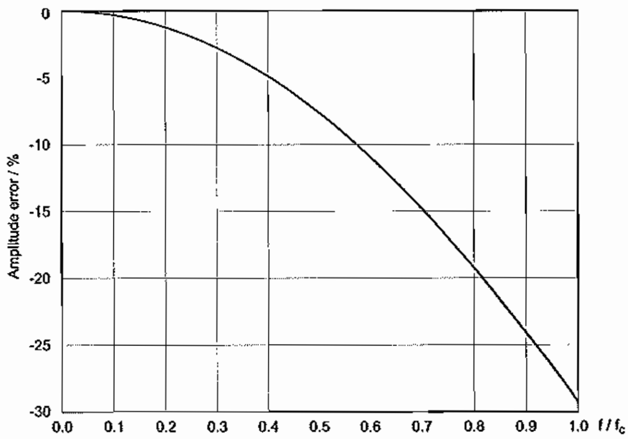

Figure C.2: Amplitude error of the low pass filter in the pass band

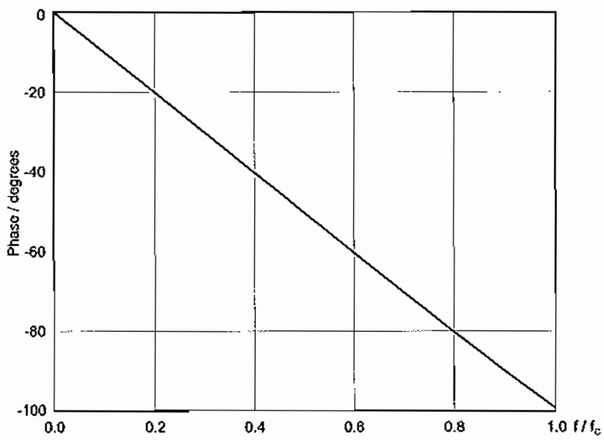

Figure C.3: Phase frequency response of the low pass filter in the pass band

C.2 High Pass Filter of the Type 4th Order Butterworth

The frequency is normalized to the cutoff frequency f_c.

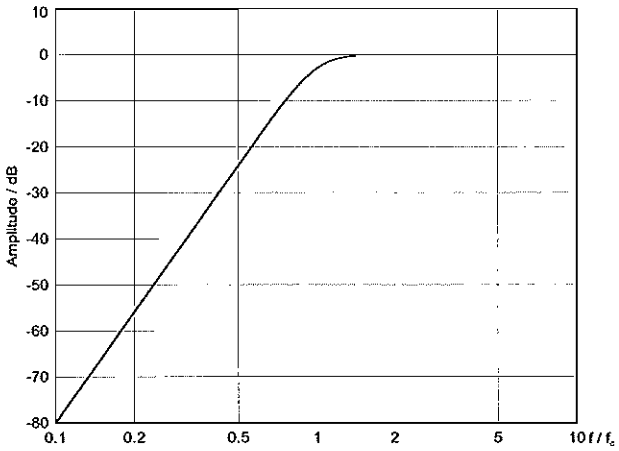

Figure C.4: Amplitude frequency response of a 4th order Butterworth high pass filter

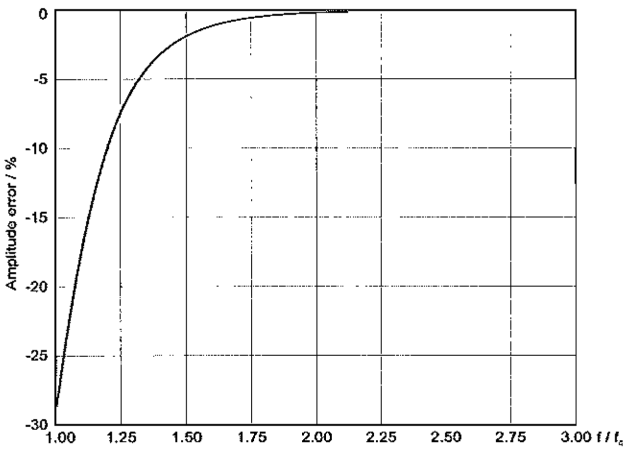

Figure C.5: Amplitude error of the high pass filter in the pass band

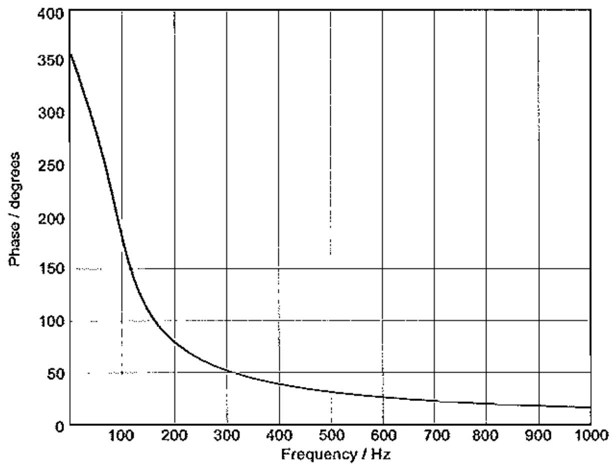

Figure C.6: Phase frequency response of the high pass filter in the pass band

Appendix D: Declaration of Conformity

CE

Konformitätsbescheinigung / Declaration of Conformity

für / for

Gegenstand / Object :	**Scanning Vibrometer** **PSV 400-B / PSV 400-H4 / PSV 400-M2 / PSV 400-M4**
Scanning Head Typ / Model :	**PSV-I-400**
Geometry Scan Unit Typ / Model:	**PSV-A-420**
Controller Typ / Model :	**OFV-5000**
Junction Box Typ / Model :	**PSV-E-401**
Data Management System :	**PSV-W-402**

Der Hersteller / The manufacturer

Polytec GmbH
Polytec Platz 1-7
76337 Waldbronn / Germany

bestätigt das Einhalten der Richtlinien 2004/108/EG und 2006/95/EG
confirms the compliance with the directives 2004/108/EC and 2006/95/EC.

Das Gerät stimmt überein mit den folgenden Normen / The unit complies to the following standards:

EN 60825-1:2003-10	Sicherheit von Laser-Einrichtungen / Safety of laser products
EN 61010-1:2002-08	Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte / Safety requirements for electrical equipment for measurement, control and laboratory use
EN 61326-1:2006-10	EMV-Anforderungen an die Störaussendung und Störfestigkeit – Elektrische Betriebsmittel für Messtechnik, Leittechnik und Laboreinsatz / EMC requirements on the Emission and Immunity – Electrical equipment for measurement, control and laboratory use Störaussendung / Emission : - **Grenzwertklasse: Klasse B / Class B** - **EN 61000-3-2, EN 61000-3-3** Störfestigkeit / Immunity : - **EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6, EN 61000-4-11**

Ausgestellt von / Issued by

Helmut Selbach

Dr. Helmut Selbach
Managing Director
Polytec GmbH

23.01.2008
Datum / Date

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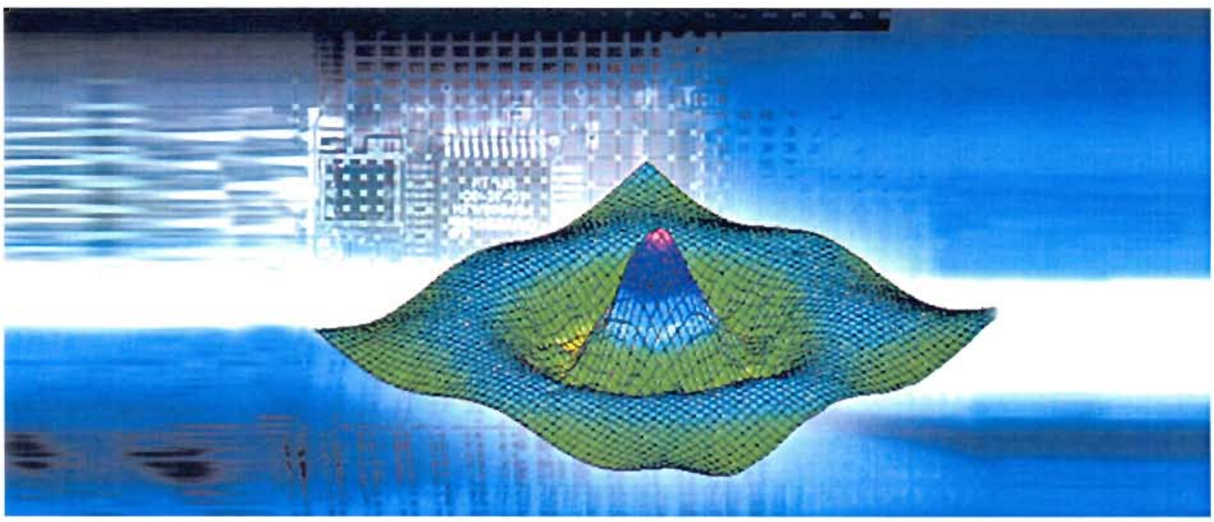
Software Manual

Polytec Scanning Vibrometer

Software 8.7



PSV

UHF

PSV-3D

MSA/MSV

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Index

1 Quick-start

This introduction will quickly familiarize you with important functions of the measurement system based on an FFT measurement. For this purpose, first of all run a scan and then evaluate it using some of the software functions. Use an object with simple geometry for the scan. If you have a function generator, use it to excite the object and then use this signal as a reference signal for the measurement. If you do not have a function generator, you can also excite it by other means.

☞ Although you can also make a measurement without a reference signal, if you do, you will not be able to animate the vibration during evaluation.

Preparation

1. Connect up the measurement system and start it as described in the hardware manual.
2. If available, connect the reference signal to the jack REF 1 on the front of the junction box.
3. Start the software. To do so, double-click the icon PSV on the desktop. You will find more information on this in SECTION 2.4.
4. If the software has not been started in Acquisition mode, go into acquisition. To do so, in the toolbar of the application window, click . You will find more information on this in SECTION 2.5. You will now see the video window at the top and an analyzer at the bottom. On the left you will see the project browser (refer also to SECTION 2.6.4 and on the right the scanning head control (refer also to SECTION 2.6.1).
5. Select Setup > Preferences. The dialog Preferences appears.
6. Display the page Devices.
7. From the list Junction Box, select the junction box which is connected to the PC.
8. If you are using a function generator, then set the connection for Generator (internal or GPIB).
9. Display the page Scanning Head.
10. In the list Scanning Head, select the scanning head you have connected.
11. Click OK.
12. Only with the option VDD: Run test mode as described in SECTION 7.7.

You will find more information on setting up the software in CHAPTER 3.

Setting the Optics

You set the optics using the scanning head control. See also SECTION 4.1 on this.

13. Point the scanning head at the object, either manually or using the optional pan-tilt stage.

14. Zoom in the video camera so that the object appears as large as possible in the video window. To do so, use the slider Zoom in the field Camera.

15. Now focus the video camera. To do so, first of all point the laser beam at the top left corner of the video image. Otherwise the light from the laser beam prevents the video camera focusing automatically. To adjust the laser beam, use the icons Position. Then click Autofocus in the field Camera.

16. Then point the laser beam at the object again.

17. Focus the laser beam with the icons ◂N and F▸. As an option, you can automatically focus the laser beam using the icon AF. You will find more information on this in SECTION 4.2.

18. Align the positions on the live video image with the position of the laser on the measurement plane. To do so, click or select Setup > 2D Alignment. The software will maximize the video window. Distribute the alignment points evenly over the whole measurement surface. If, for example, you want to scan a rectangular surface, it would make sense to choose four alignment points near the corners.

19. Move the laser beam to an alignment point on the object using the icons Position in the scanning head control.

20. In the live video image, point the mouse precisely at the laser beam and click. You can now see a target there. If the laser beam is not precisely in the middle of the target, click again.

21. Repeat steps 19 and 20 for at least three more alignment points.

22. Once you have aligned all points, click again or select Setup > 2D Alignment.

You will find further information on 2D alignment in SECTION 4.4.

☞ To be able to import 3D geometries in 3D point mode (optional), you also have to carry out a 3D alignment. See SECTION 4.5 on this.

Defining Scan Points

23. Go to scan point definition. To do so, in the toolbar of the application window, click . The software maximizes the video window and displays a graphics toolbar (the icon is activated). The dialog Object Properties appears.

24. First of all delete all scan points which may already be defined. To do so, select Edit > Select All and then Edit > Delete.

25. First click in the graphics toolbar and then draw the largest possible rectangle on the object.

26. You will see the rectangle you have drawn with a red edge and white squares which mark the edge. You will see the scan points as blue points inside the rectangle.

27. Please check whether the icon in the dialog Rectangle Properties is active. If yes, then click to display the scan points (refer also to SECTION 5.1.7).

28. Point the mouse at the grid. The cursor becomes a cross. You can now move the grid with the scan points by clicking the grid and moving it using the mouse.

29. You have now finished defining scan points. In the toolbar of the application window, click again to quit scan point definition.

30. Now point at the live video image and click a scan point. The laser beam moves to this point on the object. Click additional scan points to check and see if the laser beam is positioned precisely on the scan points.

You will find more detailed information on scan point definition in CHAPTER 5.

Setting Parameters

31. In the toolbar of the application window, click A/D. The dialog Acquisition Settings appears.

32. Display the pages in the dialog from left to right and set the parameters there. The suitable settings depend on the object. If you know suitable settings, then set them. If not, use the settings in TABLE 1.1.

Table 1.1: Parameters for an example measurement

Page	Settings
General	Measurement Mode: FFT Averaging: Off Remeasure: Active
Channels[1]	Vibrometer: Active, Direction +Z, Range 10V, Coupling DC, Quantity Velocity Reference 1: Active, Direction +Z, Range 10V, Coupling DC, Quantity Voltage
Filter	Channel Vibrometer: Filter Type No Filter, Int/Diff Quantity Velocity (0) Channel Reference 1: Filter Type No Filter
Frequency	Bandwidth: 10kHz From: 0kHz To: 10kHz FFT Lines: 400
Window	Channel Vibrometer: Function Rectangle Channel Reference 1: Function Rectangle
Trigger	Source: Off
SE	Channel Vibrometer: Active Channel Reference 1: not Active Speckle Tracking: Active Slider: Fast
Vibrometer	Velocity: lowest available measurement range Tracking Filter: Slow (Slow) Low Pass Filter: Off (1.5MHz) High Pass Filter: Off
Generator	Active: Active

[1] Only with option VDD: Some parameters on the page Channels are not available or are fixed.

33. Click OK.

You will find detailed information on the parameters for data acquisition in CHAPTER 6.

Single Point Measurement

34. If available, start signal output from the function generator. To do so, in the toolbar of the application window, click ∿.
35. Start a continuous measurement. To do so, in the toolbar of the application window, click ↻. The analyzer displays the measurement signal on the vibrometer channel.

☞ Autoscale the y-axis. To do so, in the toolbar of the analyzer, click ↕].

36. Click a scan point in the video window. The software will position the laser beam on the object at this scan point. Check whether the display OVER in the scanning head control is permanently red. If yes, then the measurement range for the velocity is being exceeded at this scan point.
37. Repeat step 36 for a few additional scan points.
38. If the display OVER is red at several scan points, increase the measurement range for the velocity. To do so, click A/D again, display the page Vibrometer and select the next highest measurement range in the list Velocity. Then click OK.
39. Repeat steps 37 to 38 until the measurement range for the velocity is no longer exceeded.
40. Stop the continuous measurement. To do so, in the toolbar of the application window, click ✋.

You will find detailed information on making measurements in CHAPTER 7.

Scanning

41. Start the scan. To do so, in the toolbar of the application window, click ⇉. The dialog Save As appears.
42. Navigate to the saving location and enter the file name.

☞ If you have the project browser displayed (refer to SECTION 2.6.4), you will then automatically be shown the directory marked there as saving location.

43. Click Save. The scan starts. The software immediately saves every scan point measured.
44. In the video window you can follow the progress of the scan. See CHAPTER 9 on this.

Displaying Data

Select data sets

45. Display a spectrum. To do so, in the toolbar of the analyzer, click and select FFT in the context menu.

46. Click to autoscale.

47. You can display other signals for spectra apart from the measurement signal. To do so, click and select Acceleration in the context menu. While is activated, the selected signal will be autoscaled directly.

48. Display the magnitude of the acceleration signal as well as its phase. To do so, click and select Mag.&Phase in the context menu.

Zoom

49. Zoom the range between 5kHz and 10kHz. To do so, point the mouse at the x-axis at 5kHz. The cursor becomes a magnifying glass.

50. Press the mouse button and drag to the right to 10kHz.

51. Undo zooming. To do so, click .

Set a cursor

52. Activate a cursor. To do so, click .

53. Set the cursor in the analyzer. To do so, click in the diagram. A vertical line will appear at the point which you have clicked.

Read data

54. You can see the cursor's coordinates in the legend. If the legend is not visible on the right in the analyzer, select Analyzer > Legend to display it.

55. Move the cursor to the right or left using the mouse. The data in the legend is updated simultaneously.

You will find detailed information on displaying data in CHAPTER 8.

Now you have finished the introduction. You will find further example measurements in SECTION 7.8.

2 First Steps

Polytec's Scanning Vibrometer measures the two-dimensional distribution of vibrations. The software in the measurement system has the following functions:

- Controlling the hardware
- Defining scan points
- Setting parameters for data acquisition
- Generating excitation signals (as an option)
- Acquiring digital data
- Saving data
- Displaying data and evaluating it

First of all, read the following sections to familiarize yourself with the basics of how to work with the software.

2.1 System Requirements

So that you can work optimally with the software, please make sure that the following components have been installed:

- For data acquisition systems, please use either Windows® XP (32 bit) or Windows® Vista (64 bit) as your operating system.

☞ Only for VibSoft-20: operating system Windows® Vista (32 bit)

☞ For desktop PCs, the operating systems Windows® XP (64 bit) and Windows® Vista (32 bit) are additionally available.

- Current Service Packs for Windows® XP or Windows® Vista
- Microsoft® DirectX® 9
- Microsoft® .NET Framework 2.0 SP1
- The respective drivers for your measurement system. You will find detailed information on this in the Release Notes on your software CD.

☞ First of all, please carry out the installations as described in the Release Notes.

2.2 Installing the Software

To install the software, proceed as follows:

☞ When installing the software, please make sure you pay attention to the supplements and special features in the Release Notes!

1. Only for a new installation: Install the required hardware as described in both your hardware manual under Cabling and in the manual for your data acquisition board.

2. Check that your hardlock (dongle) is available and has been installed correctly.

☞ While the software is being installed, you are asked to choose whether you have installed a local hardlock or a network hardlock. Please note that acquisition mode is not available with a network hardlock.

3. Switch on your PC and log in with administrator rights. See your operating system manual on this.

4. Install the required software as described in the file \\PSV\ReleaseNoteseng on your PSV DVD.

Now you have finished the installation. Should any problem occur during installation, please contact Polytec.

2.3 Integrating the Hardware

> **CAUTION!**
>
> **Danger from mishandling!** - Do not change any address or interrupt settings! This could prevent the software from running properly.

You can control two Polytec vibrometers using the software and as an option, an external function generator as well. See also in SECTION 7.8.2 or SECTION 7.8.6 on this. Connect up the devices as described in your hardware manual.

IEEE-488/GPIB

If you control some devices via IEEE-488/GPIB, then we recommend you set the following addresses:

- Vibrometer controller 1: IEEE-488/GPIB address 5
- Vibrometer controller 2: IEEE-488/GPIB address 4
- Function generator: IEEE-488/GPIB address 10.

RS-232

If you control vibrometers via RS-232, then the software recognizes the controller connected to the lower COM port as Vibrometer Controller 1.

2.4 Starting the Software

To start the software, proceed as follows:

1. Check that the hardlock has been installed correctly on the PC or on the network.
2. Connect up the PSV and start it as described in your hardware manual.
3. After you have done this, switch the PC on.
4. After a short while you will be asked to log in. You do not need administrator rights to start the software. See your operating system manual on this or contact your administrator.

☞ If you want to change the hardware, you have to log in as administrator. A password has not been set prior to delivery.

5. Double-click the icon PSV on the desktop or select Start > PSV. The application window appears.
6. Change to acquisition mode. You may receive an error message and information on it (refer to SECTION 2.5).

You can now work with the software.

2.5 Modes in the Software: Acquisition and Presentation

In the software you work in two different modes: Acquisition and Presentation. You can use some functions in both modes. Acquisition mode is not available in the desktop version.

Presentation mode

To go to presentation mode, click or select View > Presentation.

Acquisition mode

To go into acquisition mode, click or select View > Acquisition.

When changing into acquisition mode, the software searches the PC interfaces for external devices and initializes them. You may receive an error message and information on it. You can switch off this error message as described in SECTION 3.7.

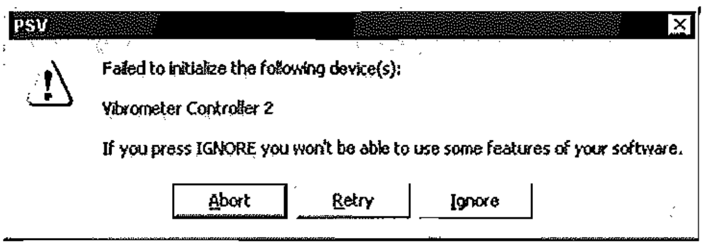


Figure 2.1: Error message when changing into acquisition mode

If you want to check the connection between the devices and if necessary correct it, select Setup > Preferences and open the page Devices.

☞ Some Polytec instruments are automatically initialized in acquisition mode and can not be changed. But when changing into presentation mode, all the hardware used is enabled. This makes it easier to use the PSV software in parallel to PMA or TMS software for example in the case of MSA systems.

2.6 Windows in the Software

First of all, read the following sections to familiarize yourself with the various windows in the software.

- Application Window, refer to SECTION 2.6.1
- Video Window, refer to SECTION 2.6.2
- Analyzer, refer to SECTION 2.6.3
- Project Browser, refer to SECTION 2.6.4
- Presentation Window, refer to SECTION 2.6.5
- Signal Processor, refer to SECTION 2.6.6
- Arranging Windows, refer to SECTION 2.6.7
- Zooming in Windows, refer to SECTION 2.6.8

2.6.1 Application Window

After starting the software, the application window appears. At the top you will see the title bar, menu bar and toolbar, at the bottom the status bar. In the menu View, you can show (hide) the toolbar and the status bar.

Initially the application window is empty. You are in presentation mode. Click to quickly create new signal processor documents, new combined files or new scan files.

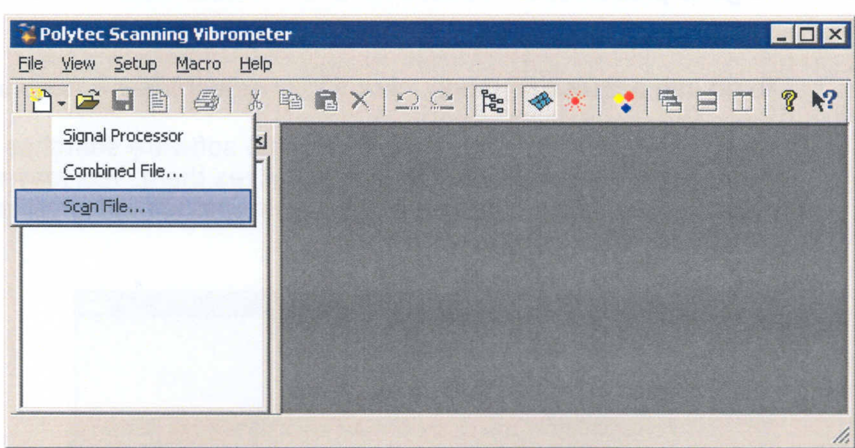


Figure 2.2: Example of the application window in presentation mode

By clicking you change into acquisition mode. There you will see the video window, an analyzer and the project browser. The windows are described in the following sections in detail. Click to display additional analyzers.

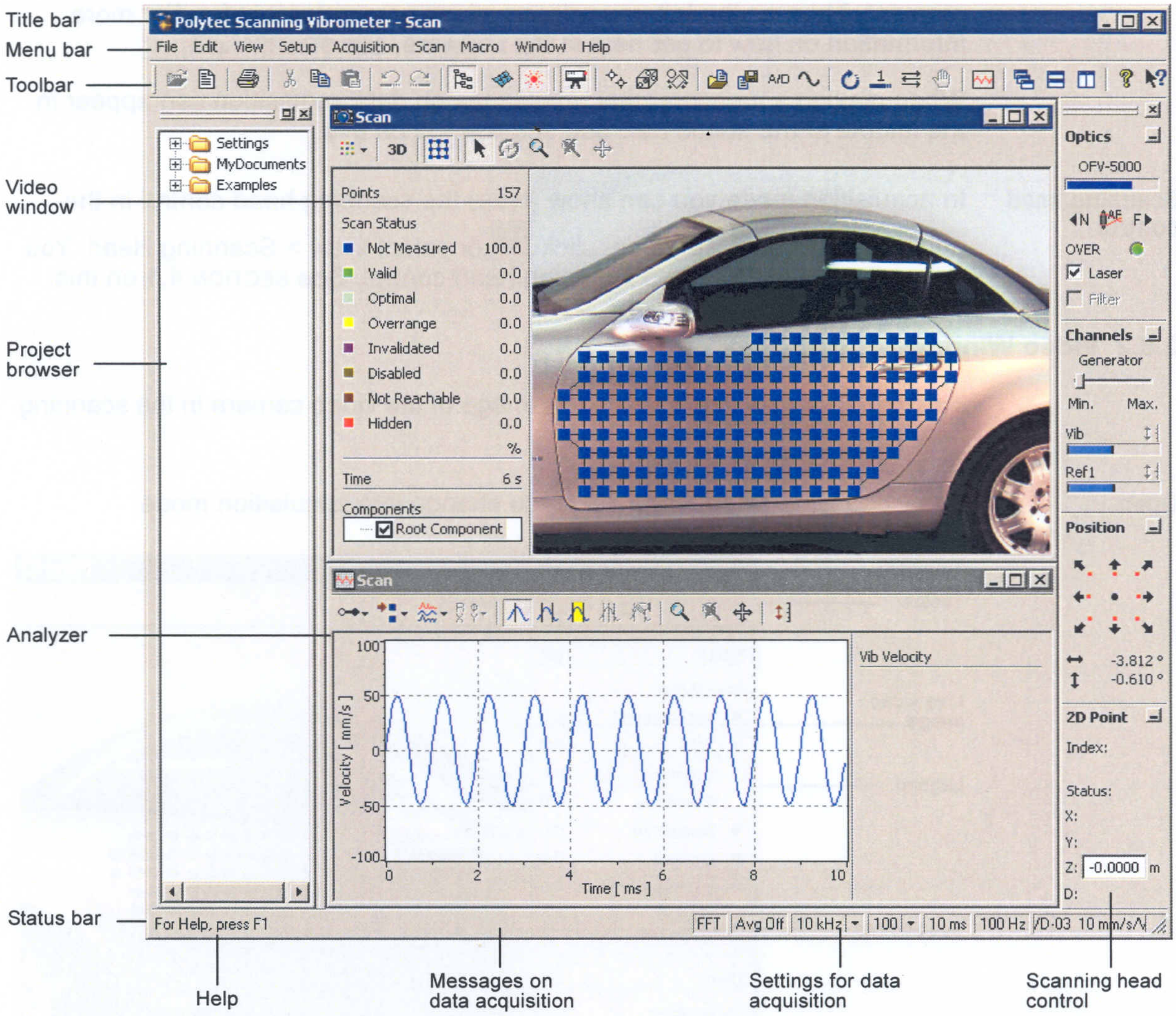


Figure 2.3: Example of the application window in acquisition mode

In the application window you can display and evaluate data. To do so, you can use various windows:

- In acquisition mode: a video window, any number of analyzers.
- In presentation mode: any number of presentation windows and analyzers.

If you restart the software, then the arrangement and signal selection of the windows opened most recently will be restored. Please read SECTION 2.6.7 on how to set the window layout.

Menu bar Every menu contains a group of commands for working with the software. Some menus are only visible if an analyzer or a presentation window is open.

Toolbar By clicking the icons, you can execute some commands quickly which you would otherwise have to select in the menus.

Status bar On the right, the status bar shows several settings for data acquisition. On the left, in certain situations, you will see a short help text. For example, point the mouse at one of the settings on the right and leave the cursor there for a moment. Then on the left you will see which parameter it is for. For more information on how to get help in the software, see SECTION 2.8.

When making a measurement, messages on data acquisition can appear in the middle of the status bar. See SECTION 7.5 on this.

Scanning head control In acquisition mode you can show (hide) the scanning head control in the application window. To do so, click or select View > Scanning Head. You adjust the optics using the scanning head control. See SECTION 4.1 on this.

2.6.2 Video Window

The video window displays the live image of the video camera in the scanning head.

Open The video window appears when you change into acquisition mode.

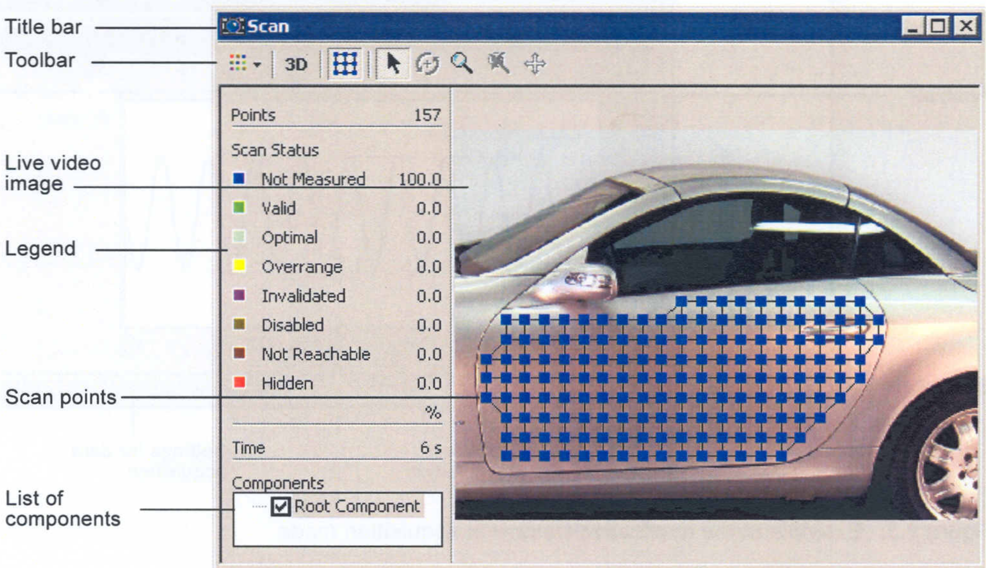


Figure 2.4: Example of the video window

Toolbar By clicking the icons, you can execute some commands quickly which you would otherwise have to select in the menus.To change between the 2D view and the 3D view, click 3D. If you change from the 2D view to the 3D view, a snapshot of the live video image is shown as a fixed-image. You can also use the mouse to set the line of sight directly in the video window. To do so, click . The mouse cursor becomes a . Drag in the direction you require.

To change the view of the scan point status, click ⁝⁝⁝▾. Please see SECTION 7.3 on this as well.

Live video image In the live video image, you control the position of the laser beam. Apart from that, you define there scan points and follow the progress of a scan. You adjust the image settings of the live video image (contrast, brightness, color) as described in SECTION 4.3.

Legend On the left you see a legend for the status of the scan points. The legend also shows the number of defined scan points and the estimated time needed for the scan. The display of the status changes depending on which view you have selected (Scan, Geometry or Laser Focus).

Scan points If scan points are defined, you can show (hide) them in the video window. To do so, click ⁝⁝⁝ or select Scan > Scan Points. You see the scan points as markers in different colors. These colors show the status of the scan points.

List of components In acquisition and presentation mode you can define geometry components and assign scan points to the single components. See also SECTION 5.4.3 on this.

Zoom function In the video window you can zoom in on image sections and can pan the zoomed sections. You will find the necessary tools in the toolbar of the application window, refer also to SECTION 2.6.8.

2.6.3 Analyzers

Analyzers show measurement data and evaluated data in x-y diagrams. You can follow current measurements in analyzers or use them to display measurement data from a file. In presentation mode, an analyzer can also be part of a presentation window. See SECTION 2.6.5 on this.

Open An analyzer appears if you

- start a single shot or a continuous measurement or
- open a single point measurement.

If an analyzer is open, the menu bar of the application window is extended by menus for working with analyzers. To open further analyzers, click [icon] or select Window > New Analyzer.

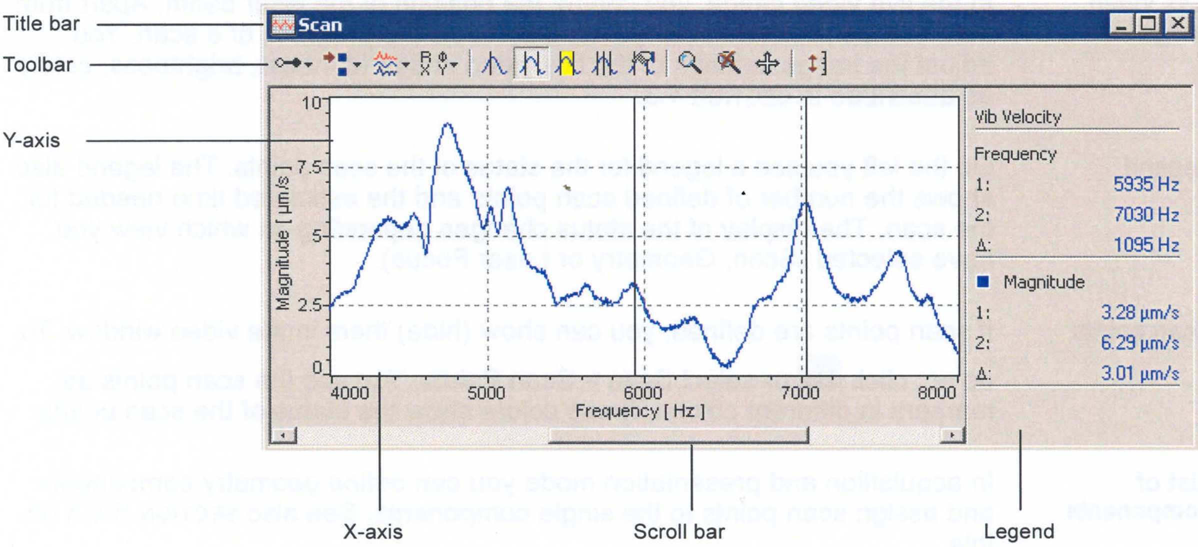


Figure 2.5: Example of an analyzer

Title bar If an analyzer has the function of a measurement window, you will see the name Scan in the title bar. If you have already saved the measurement or have opened a single shot or a continuous measurement, you will see the file name in the title bar.

Toolbar You can show/hide the toolbar by selecting Analyzer > Toolbar. By clicking the icons you can quickly execute some commands from the menu Analyzer.

Diagram You can see the data as a graph in x-y diagrams. You can set up the look of the diagrams and the graphs yourself.

Legend On the right you can show/hide a legend for the diagrams. To do so, select Analyzer > Legend.

Zoom function In the analyzer you can zoom on diagram sections and can pan the zoomed section. In the toolbar of the analyzer you will find the necessary tools, refer also to SECTION 8.2.1.

Scroll bar You can use the scroll bar to scroll if you have zoomed the x-axis.

2.6.4 Project Browser

In the project browser you can display folders in a tree structure with the subdirectories and files in them. To do so, open a program on file management, e.g. Microsoft® Explorer and use the mouse to drag the required folder or folders into the project browser. These folders can now be managed from here. In these folders, you can also create new subfolders. Please note that all actions are executed directly in the respective folder.

☞ The folders in the project browser are not copies, but are direct links to folders on your hard disk or network drives! Changes made in the project browser, e.g. deleting or renaming subdirectories and files are carried out in parallel in your file management and in reverse.

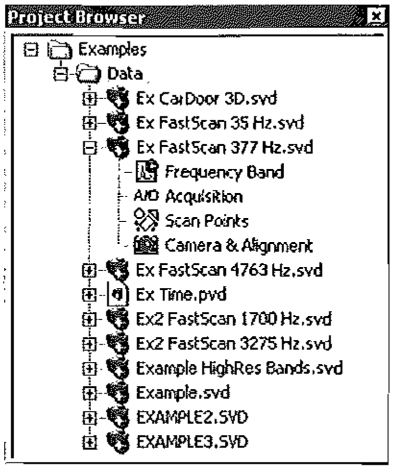


Figure 2.6: Example of the project browser

☞ You can not transfer individual files to the project browser. You can remove folders again. To do so, click the folder with the right mouse button and select Remove in the context menu. You can also delete individual files.

The contents of the project browser remain saved, even after the program is stopped. The display of contents is user-specific.

Open

To open the project browser, click or select View > Project Browser. You can adapt the way the project browser is displayed, i.e. make it smaller and move it to another part of the screen. If you drag the project browser near to one of the edges of the software window and release the mouse button, the project browser is automatically placed next to the corresponding window edge. Click in the title bar of the project browser to reduce its size again and position it freely in the software window.

Add folder

To add another project folder to the project browser, click the project browser with the right mouse button, however do not click a file or a folder. Select Add Project Folder in the context menu. The dialog Select Folder appears. Navigate to the required folder and click Select.

☞ Alternatively you can also select File > Add Project Folder.

Click a file or a folder with the right mouse button to edit the contents in the project browser. The commands shown in the context menu differ depending on the level in the tree structure, the type and number of objects selected and the mode you are currently working in (acquisition or presentation). The individual commands are explained in the following.

Explorer: Click here if you want to have the selected folder displayed in Microsoft® Explorer as well. This command is only available for folders.

New Folder: Click here if you want to create a new subfolder in the selected folder. The subfolder appears in the project browser and can immediately be renamed respectively.

Refresh: Click here to update the display of folders and files in the project browser.

Remove: Click here if you want to remove the selected objects from the project browser, but do not want to delete them. The command is only available for folders on the top level.

Rename: Click here if you want to give the selected object a different name.

Delete: Click here if you want to irrevocably delete the selected objects. Before deleting them permanently, you have to confirm a safety check. The command is only available for files.

☞ You can only delete settings if they are saved in their own file (*.set) (refer to SECTION 10.2.7 and SECTION 10.1.4). You can not delete the settings of a scan.

Load: If you select Load, then the setting files (.set) that you selected in the project browser are loaded. See also SECTION 10.1.4 on this.

Open: In principle, in the project browser you can open files from all programs installed on your PC. Click Open and the selected file will be opened using the corresponding program. If you open a file with the suffix svd, a presentation window appears. If you open a file with the suffix spd, the signal processor appears (as an option).

New window: Click here if you want to display the file you have already opened in a second window again.

Info: Click here if you want to display the file information on the file you have already opened. See also SECTION 10.1 on this.

Close: Click here if you want to close the selected file.

Save As: Click here if you want to save the selected file under a different name or in another directory.

Create Scan File: Click here if you want to create a new scan file from the selected file in the format Scan Data (svd), Settings Files (set), Universal Files (unv), or ME'Scope Files (str). A condition of this is that the file contains a 3D geometry. Only the 3D geometry is then transferred to the new scan file. You can now add user-defined data sets and then save the file.

Paste: This command is only available if you are using the optional signal processor (refer also to SECTION 8.6). If you have copied data in the signal processor, you can insert this data into the selected file by using the command Paste.

Edit: If you select Edit, a macro window will appear with the macro you selected in the project browser.

Run: If you select Run, then the macro you selected in the project browser is executed.

Properties: This command is only available to you for combined files in presentation mode. You will then see the dialog Create Combined File with the individual files in the set order. See also SECTION 8.5 on this.

Import: In the project browser, you can also import geometries in the format Universal File, ME'Scope or ASCII. A condition of this is that you are in acquisition mode, you have a valid 3D alignment and you have selected point mode in the scan point definition. See also SECTION 5.2.8 on this. Apart from that, in presentation mode you can also import measurement data in the format Universal File, ME'Scope or ASCII. See also SECTION 10.1.5 on this.

Copy and move

You can copy files or folders in the project browser into other directories. To do so, mark them and holding the left mouse button pressed, drag the marked objects onto the required directory.

To move files or folders in the project browser, proceed as described above. Also hold the shift key pressed while you are dragging with the mouse.

2.6.5 Presentation Window

In presentation windows you analyze scans in 2D and 3D diagrams.

Open A presentation window appears when you open a scan. The menu bar of the application window is then extended by menus for working with presentation windows. You can then open further presentation windows by selecting Window > New Window.

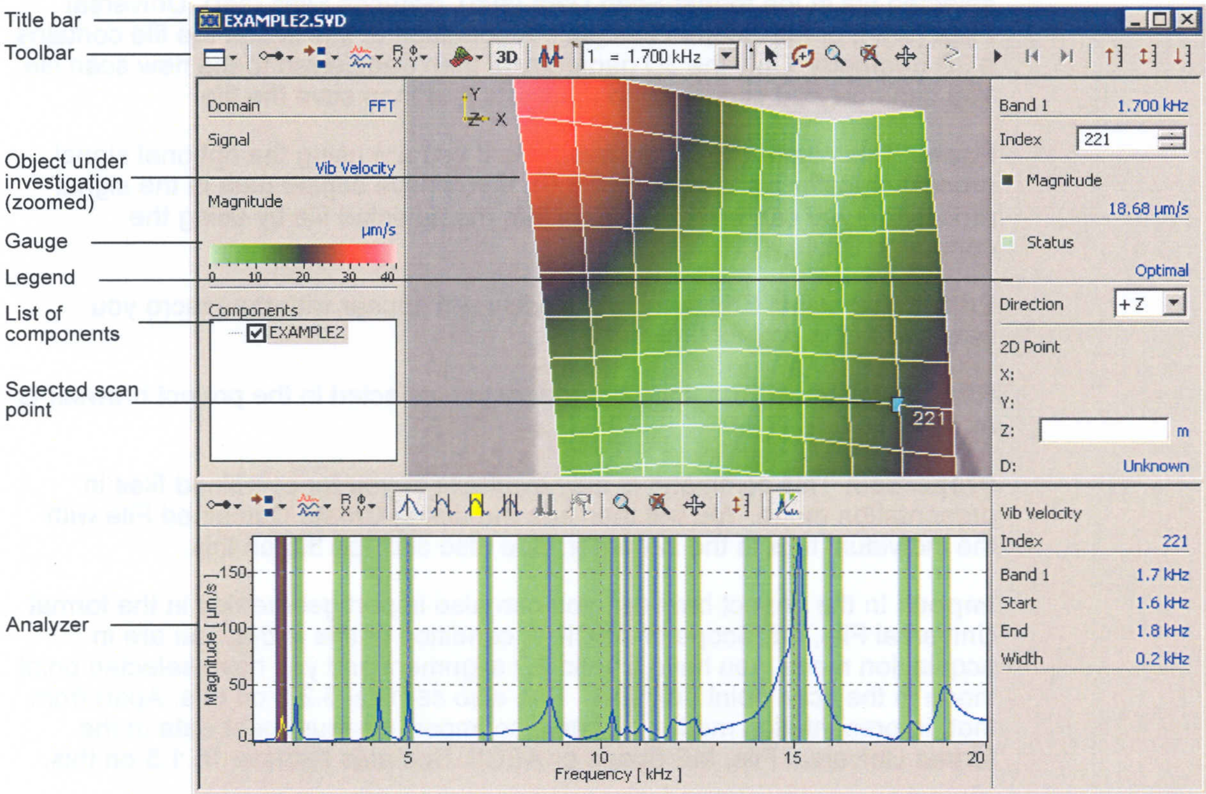
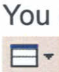


Figure 2.7: Example of a presentation window in the Single Scan Point view

Toolbar You can show (hide) the toolbar by selecting Presentation > Toolbar. By clicking the icons you can quickly execute some commands from the menus Setup, Presentation and Animation.

View You can display the presentation window in different views. To do so, click  and select the view required in the context menu. You can also select Presentation > View.

Object You see the object in all views. You can present the object in different ways. To do so, click  and select the view style required in the context menu. You can also select Presentation > View Style.

Gauge On the left you can show/hide a gauge for color-coding. To do so, select Presentation > Gauge.

Legend On the right you can show/hide a legend for the data displayed. To do so, select Presentation > Legend.

List of components In acquisition and presentation mode you can define geometry components and assign scan points to the single components. See also SECTION 5.4.3 on this.

Analyzer In the views Single Scan Point, Average Spectrum and Profile you will see an analyzer at the bottom of the presentation window. See SECTION 2.6.3 on this.

Zoom function In the presentation window you can zoom on the object in all views and in all view styles and also pan the zoomed section. You will find the necessary tools in the toolbar of the presentation window, refer also to SECTION 2.6.8.

2.6.6 Signal Processor (as an Option)

You can use the signal processor to recalculate measurement data for further analysis and then compare the results with the original data. You can read SECTION 8.6 to find out how to work with the signal processor.

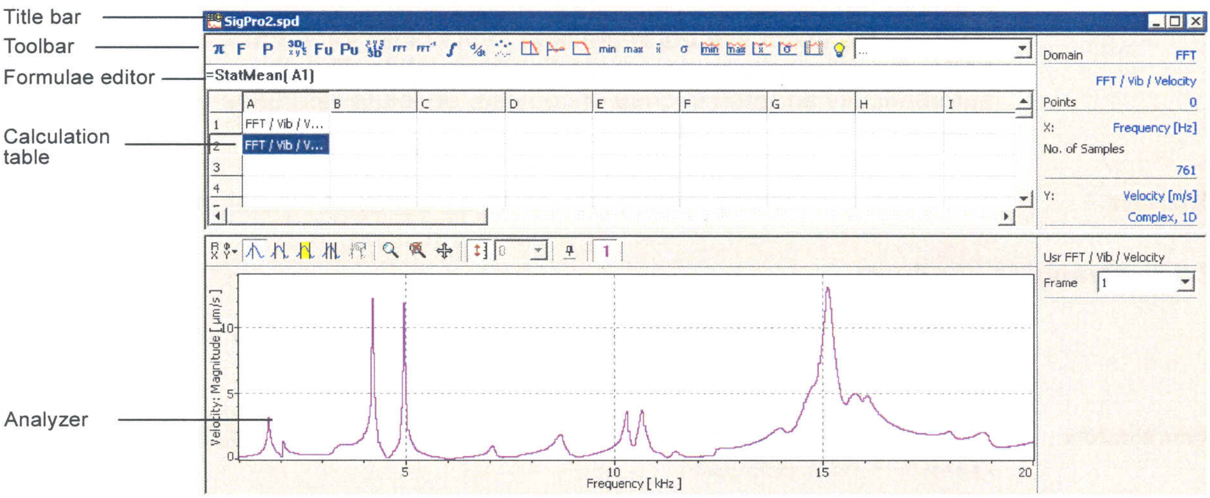


Figure 2.8: Example of recalculating measurement data in the signal processor

Toolbar In the toolbar you will find the most important arithmetic operations you can execute with the signal processor. By clicking the icons, you can transfer the formulae directly to the formulae editor instead of having to enter them using the keyboard. The icons are active as soon as the cursor is in the formulae editor. You can also select the function wizard to enter the formulae. To do so, click and then the required icon. See also SECTION 8.6.1 on this. Apart from the icon for the function wizard, you will find a list with all available formulae. By clicking in the list, you can directly apply the formula in the formulae editor.

Formulae editor You are shown the contents of the selected table cell in the formulae editor. This is also where you enter text or formulae which are to appear in the selected cell.

Calculation table You enter the measurement data and the formulae in the cells of the calculation table. By linking the individual cells via the formulae, the software can make various arithmetic operations using the measurement data and then display the results at any point in the computing chain. Apart from that, you can also enter comments into the cells.

☞ In the table cells, you can display either the formula or the result. To switch over, select View > Formulae or press the key combination Ctrl+#.

For linking individual cells you establish references. A reference designates a cell or a cell range in the table and informs the signal processor where the values or data used in the formula are located. With the aid of references you can use data or values of a cell in different formulae.

Depending on the operation that you want to execute in the signal processor, you can either use relative or absolute cell links. Relative cell links are references to cells that are given in relative to the position of the formula, absolute references are cell links that always refer to cells at a certain position. If a dollar symbol is prefixed to the letter and/or the number, e.g. A1, then the column and/or cell link is absolute. Relative references are automatically adapted in case of copying, absolute references are not adapted.

Analyzer The signal processing results are shown as a graph in the analyzer.

2.6.7 Arranging Windows

You can arrange all open windows in the application window using the commands in the menu Window.

New window To open further analyzers or presentation windows, click [icon] or select Window > New Analyzer.

Cascade You can arrange all windows over each other so that only the title bar and the y-axis name are visible respectively. To do so, click [icon] or select Window > Cascade.

Tiling horizontally and vertically You can display all open windows so that they are completely visible and maximum size. To do so, click [icon] or [icon]. You can also select Window > Tile Horizontally or Window > Tile Vertically.

Close all To close all open windows, select Window > Close All.

Window list At the bottom of the menu Window you will find a list of open windows. To activate a window – i.e. move it to the foreground – click it in the list.

Window settings

Window settings which you have made are automatically restored by the software when you newly open the file. For this purpose, the window settings are saved in a database under the complete path name of the file. This database is located on the local hard disk of your PC. Each user which is logged in Windows has its own database.

You can deactivate restoring the window layout and take over the settings of the active window as default for opening other files. To do so, first you have to change to presentation mode. Then select Setup > Preferences. The dialog Preferences appears. Display the page Display.

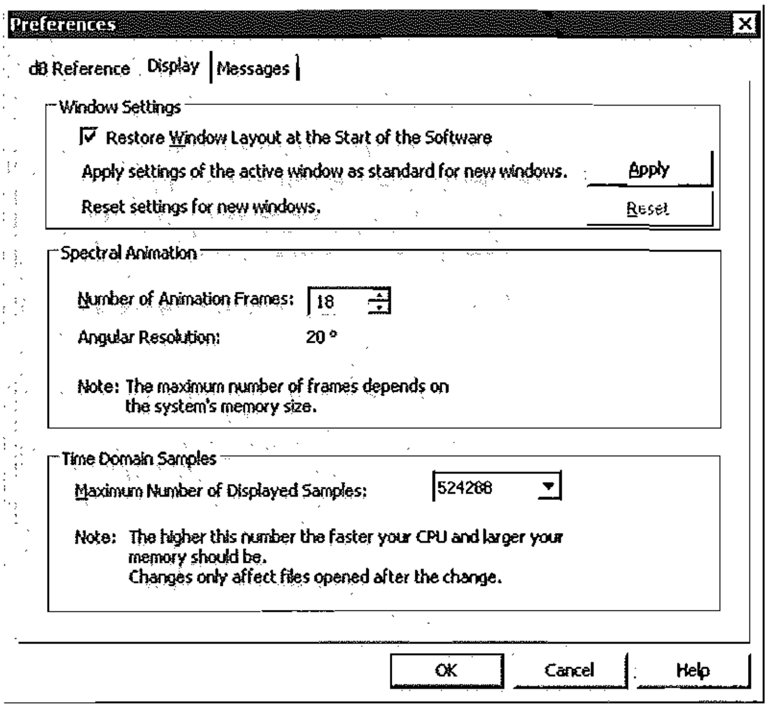


Figure 2.9: Page Display in the dialog Preferences

Restore window layout at start of the software: Tick this box in order that, at the next start of the software, the window layout will be restored like it was during exiting the software.

Apply: Click here if you want to apply the window settings of the active window (only presentation window) to other files of the same type. To activate the window, click it. The window settings are applied to every newly opened file.

☞ In acquisition mode you can only load window settings from setting files. See SECTION 10.1.4 on this.

Reset: Click here if you want to reset the window settings for newly opened files to default values.

☞ The software needs a few minutes to open files in which the window settings are to be restored. You can not abort the process.

2.6.8 Zooming in Windows

You can zoom on image sections in both the video window and also in the presentation window. You will find the necessary tools in the toolbars of the application window and of the presentation window.

Zoom

If you would like to take a closer look at a certain image section in either the video or the presentation window, you can zoom on it.

Zooming in on the object helps you define the points and carry out 2D or 3D alignment more accurately, thus enabling you to present the data more precisely. This is an advantage, particularly if your object under investigation has complex geometry or if your scan points are very close together.

To zoom in on a video or presentation window, proceed as follows:

1. Click 🔍. The mouse cursor becomes a magnifying glass with a plus sign.
2. Holding the left mouse button pressed, draw a rectangle around the area of the image which you want to zoom in on. You can repeat this step several times.

☞ If you zoom in the video window, on the left in the legend a smaller view of the measurement object will appear with a frame marking the zoomed section of it. This means you can always ascertain which part of the object under investigation you are currently viewing. Once maximum magnification has been attained, you will receive a message.

or

3. You can also zoom by scrolling with the middle mouse button (mouse wheel).

Pan the image section

You can pan the zoomed image section.

☞ Depending on the video board, the image section selected may not pan smoothly, but may move across the screen in small jumps.

Window settings

Window settings which you have made are automatically restored by the software when you newly open the file. For this purpose, the window settings are saved in a database under the complete path name of the file. This database is located on the local hard disk of your PC. Each user which is logged in Windows has its own database.

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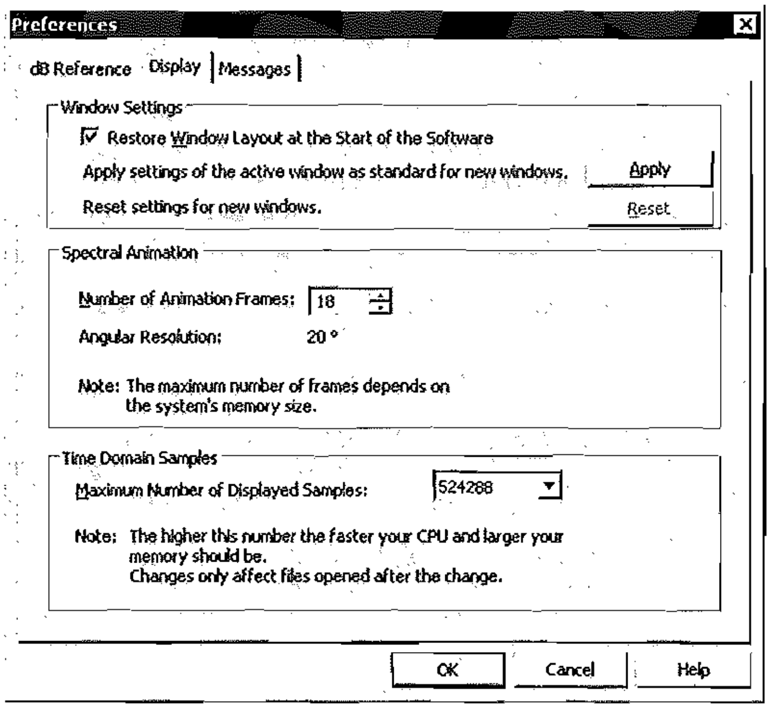

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Apply: Click here if you want to apply the window settings of the active window (only presentation window) to other files of the same type. To activate the window, click it. The window settings are applied to every newly opened file.

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Zoom

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Zooming in on the object helps you define the points and carry out 2D or 3D alignment more accurately, thus enabling you to present the data more precisely. This is an advantage, particularly if your object under investigation has complex geometry or if your scan points are very close together.

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1. Click 🔍. The mouse cursor becomes a magnifying glass with a plus sign.
2. Holding the left mouse button pressed, draw a rectangle around the area of the image which you want to zoom in on. You can repeat this step several times.

☞ If you zoom in the video window, on the left in the legend a smaller view of the measurement object will appear with a frame marking the zoomed section of it. This means you can always ascertain which part of the object under investigation you are currently viewing. Once maximum magnification has been attained, you will receive a message.

or

3. You can also zoom by scrolling with the middle mouse button (mouse wheel).

Pan the image section

You can pan the zoomed image section.

☞ Depending on the video board, the image section selected may not pan smoothly, but may move across the screen in small jumps.

To do so, you have the following options:

1. Using the middle mouse button (mouse wheel), click in the zoomed view in the video window. Hold the mouse button pressed and pan the image section. If you have given the middle button a special function (e.g. double-click), then you will have to proceed as described in step 2.
2. In point mode (APS, refer to SECTION 5.22) and during 2D alignment (refer to SECTION 4.4), click and pan the image section while holding the left mouse button pressed.

Zoom out

You can zoom out again.

To undo zooming, scroll up with the middle mouse button (mouse wheel). To undo all previous zoom actions at once, click .

Exit zooming

To leave the zoom function again, click . The last image section selected remains.

2.7 Printing

You can print out analyzers, presentation windows and signal processors. The title of the window as well as the date and time are automatically printed as a header.

Print setup

To set the paper size, feed and orientation, select File > Print Setup. The dialog Print Setup appears. Here you can select the current printer and set up the page.

Preview

To see a print preview, select File > Print Preview.

Start

To print out the active window (analyzer or presentation window), click or select File > Print. If you want to print out a signal processor or if you have selected the view Single Scan Point, Average Spectrum or Profile in the presentation window, you can define whether you only want to print one of the graphics or both. The dialog Print will then appear. Here you can select the printer and set up further print properties. To start printing, then in the dialog Print click OK.

2.8 How to Get Help

You can get help in the software as online help and through short explanations of commands. You can also display the version of the software and the software options which are installed.

Online help

To open the online help, click ? or select Help > Contents.

Context-sensitive help

For dialogs and windows you can get context-sensitive online help. To do so, proceed as follows:

1. Activate the window or dialog you need help with. To do so, click it.
2. Press the key F1. The corresponding page of the online help appears.

or

When a dialog is open, then click Help in this dialog. The corresponding page of the online help appears.

Explanation of commands

You can also get explanations for icons and commands without opening the online help. To do so, point the mouse at the command or the icon and leave the cursor there for a moment. The explanation appears on the left in the status bar. For icons you will also see a brief description on a yellow background next to the cursor.

Software version and options

To display the version of the software, select Help > About PSV. The dialog About Polytec Scanning Vibrometer appears. To display the installed software options, click Options in the dialog.

You can also display information on the operating system, the memory and on the available space on the hard disk. To do so, click System Info.

2.9 Controlling the Hardware with the PSV-A-PDA (as an Option)

With the optional PSV-A-PDA you can also call up several software functions, such as focusing the laser beam, defining and deleting scan points, etc.

Read SECTION 2.9.1 on starting the PDA.

Read SECTION 2.9.2 on setting the IP address of the network board in the PDA.

2.9.1 Starting the PDA

To start the PDA and to call up the required function, proceed as follows:

1. Install the PDA as described in your hardware manual.
2. Make sure that your WLAN Access Point is ready to use and switch it on as described in your hardware manual.
3. Switch the PSV on and start the PSV software.
4. Switch the PDA on.
5. Switch WLAN on the PDA on as described in the manufacturer's manual.

☞ Setting up the WLAN connection can take several minutes. You can not connect the PDA to the PSV software until the WLAN connection has been made. The WLAN connection is shown with an icon in the title bar.

6. Select Start > PDASoft.
7. If you want to activate the connection to the PSV software, click Yes in the pop-up message. The user interface of the PDA software appears.

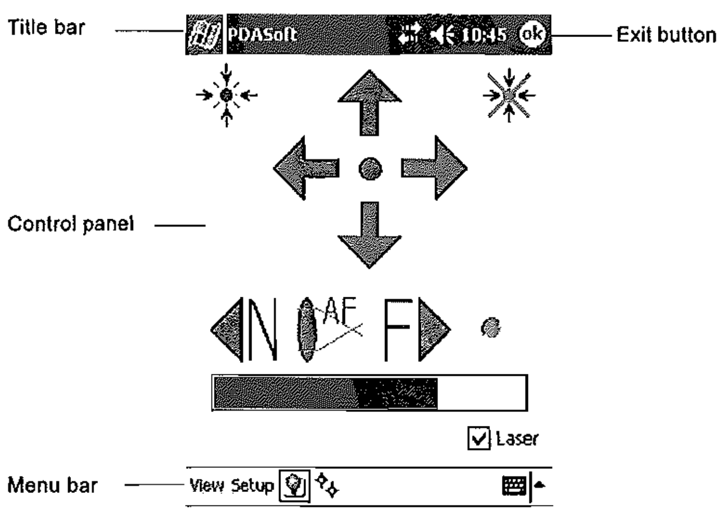


Figure 2.10: User interface of the PDA software

Control panel You can use this control panel to call up and execute the PDA functions. You will find more information on this in SECTION 4.4 AND SECTION 4.5.6.

Menu bar

The menu bar contains additional functions. You will find more information on this in SECTION 2.9.2. Apart from that, you make the connection to the PSV software here. To do so, touch the icon . Near the icon the PDA software shows in which mode you are in the PSV software (2D alignment , 3D alignment , scan point definition , acquisition mode or presentation mode).

Exit button

Touch the icon to exit the PDA software.

Functions

The PDA supports the following software functions:

- Controlling the optics (refer to SECTION 4.1.2)
- Switching the scanning heads (only PSV-3D, refer to SECTION 4.5.6)
- Defining and deleting alignment points (refer to SECTION 4.4 and SECTION 4.5.6)
- Defining and deleting scan points (refer to SECTION 5.2.2)

2.9.2 Adapting the IP Address

So that the PDA can communicate with the PSV software, the IP address of the network board which the WLAN Access Point is connected to must be entered in PDA. On delivery of the PSV system, the correct IP address is set. If you have to change this address at a later point in time, select Setup > Settings in the menu bar of the PDA. The dialog Settings appears.

☞ You can only change the IP address if the PDA is not connected to the PSV software. If required, touch the icon to disconnect it.

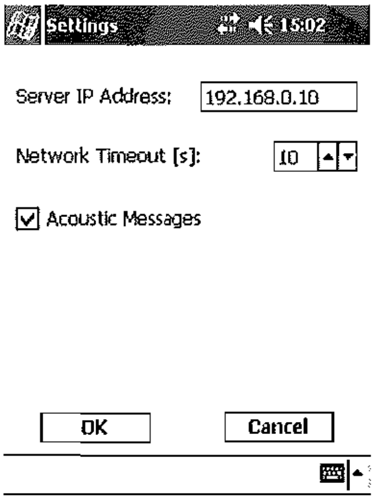


Figure 2.11: Dialog Settings

Server IP Address: Here you enter the new IP address via the keyboard in the PDA. To display the keyboard touch the icon .

Network Timeout: Here you select the time in seconds that the software has to wait until a message is issued. We recommend the presetting of 10 seconds.

Acoustic Messages: Tick this check box if you want to hear an acoustic message when you are setting/deleting a scan or alignment point or when a message is issued.

3 Setting up the Software

Before you make a measurement, you have to set up the software for data acquisition.

☞ In almost all views and modes, you can use the right mouse button to call up additional menus which contain several commands and functions that are often needed at this point.

To set up the software, proceed as follows:

1. Go into acquisition mode. To do so, click or select View > Acquisition.

☞ You can also set some options in presentation mode.

2. Select Setup > Preferences. The dialog Preferences appears.
3. The dialog contains several pages, each with a group of parameters. To display a certain page, click the name of the group.
4. Set the parameters on all pages. You will find information on this in the following sections:
   - Devices setup in SECTION 3.1
   - Channel settings in SECTION 3.2
   - Scanning Head settings in SECTION 3.3
   - Geometry and window settings in SECTION 3.4
   - Lens Calibration (only MSA) in SECTION 3.5
   - Settings for dB Reference in SECTION 3.6
   - Messages in the software in SECTION 3.7
5. When you have set all parameters, click OK.

Test mode (only MSA/MSV with option VDD)

6. If you have installed the option VDD for the MSA/MSV (with VDD decoder), run the test mode. See SECTION 7.7 on this.

PSV-3D

The measurement system PSV-3D enables you to measure and display vibration vectors in three dimensions.

☞ The settings in the software apply for all three controllers respectively. For this reason, no distinction is made between the individual devices on the user interface.

Background measurement for UHF

For the UHF, you can carry out background measurements to attenuate for the measurement spectral impurities generated by the oscilloscope. For a background measurement you proceed as follows:

1. Ensure that the sample is not excited, i.e. does not vibrate.
2. Select Setup > UHF Background Measurement. You will be asked to disconnect the excitation from the sample.

   Then a measurement of the resting sample is carried out. The excitations found in the measurement are no signals of the vibrating sample but spectral impurities of the oscilloscope. These spectral impurities will be corrected in the following measurements.
3. You can now start a single point measurement or a scan. Read SECTION 7.1 or SECTION 7.2 on this.

Please pay attention that you have to regenerate the background measurement if you:

- restart the software.
- disconnect and reconnect the vibrometer controller. Read also SECTION 3.2 on this.
- change the Bandwidth or the FFT Lines with a measurement in FFT mode. Read also SECTION 6.2.4 on this.
- change the Sample Frequency or the Samples with a measurement in Time mode. Read also SECTION 6.2.12 on this.

3.1 Devices

On the page Devices you set which measurement system and which external devices you want to control with the software.

Depending on the measurement system and equipment, the page Devices may look different.

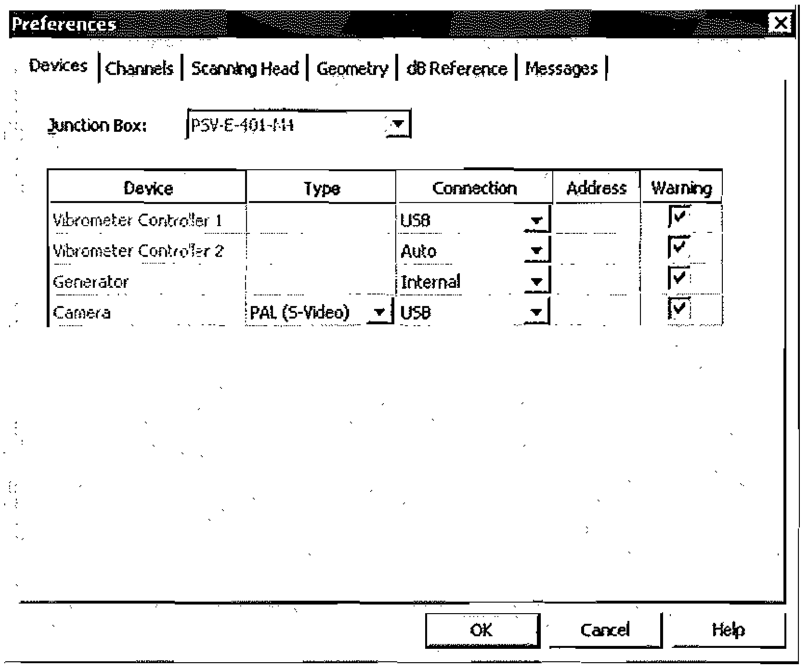


Figure 3.1: Page Devices

Junction Box: This list is only active for certain hardware configurations. Junction boxes connected via the USB interface are recognized automatically and displayed.

☞ If you have the option of changing the hardware selection, you have to log in as an administrator to change it.

To use the option VDD for MSA/MSV, you must select the junction box VDD-Z-010, VDD-Z-011, VIB-E-400-VDD, MSA-E-500 (VDD), or MSA-E-40x (VDD).

☞ OFV-5000: To be able to run the test mode automatically, the controller has to be controlled remotely via USB and has to be connected with VDD Vib Controller 1 on the page Channels (refer to SECTION 3.2).
OFV-3001: In this case it is not possible to connect up a controller which is remotely controlled. There is only a connection to the reference signal, not the vibrometer signal.

Device: Here the connected external devices are displayed.

Type: Here you select the camera type PAL or NTSC that you are using. If you are using the junction box PSV-E-401 or PSV-E-401-3D, here you have to select the camera PAL (S-Video) or NTSC (S-Video).

Connection: Here you can select which interfaces should be searched to look for external devices. For the vibrometer controllers you have to state where the devices are connected (RS-232 or GPIB). If the vibrometer controller is connected via the USB interface, it will be recognized automatically. Then you do not have to make any more settings for this controller. If you are using a generator, you can also state whether the device is integrated into the PC (internal) or whether it is an externally connected device.

Address: If you have given a fixed connection, then select the address here or carry out an automatic search for it (Auto).

Warning: If you change into acquisition mode or have changed any settings, then the software will search the PC's interfaces for external devices and initialize them. Here you mark the devices which you want a warning message issued for if the software can not find them.

☞ These warnings are not shown if under Setup > Preferences on the page Messages you have selected Errors or Show None respectively (refer also to SECTION 3.7).

Activate PSV-3D

You can operate the PSV-3D in 1D mode (PSV-3D (1D)) and in 3D mode (PSV-3D (3D)). In contrast to 3D mode, in 1D mode the signals of every scanning head are displayed and processed without transforming the coordinates. The channels measured are designated as Vibrometer Top, Vibrometer Left and Vibrometer Right.

PSV-3D in 3D mode

To activate the PSV-3D in 3D mode, select the junction box PSV-E-401-3D or PSV-E-400-3D.

☞ If you want to change the hardware selection, you have to log in as administrator.

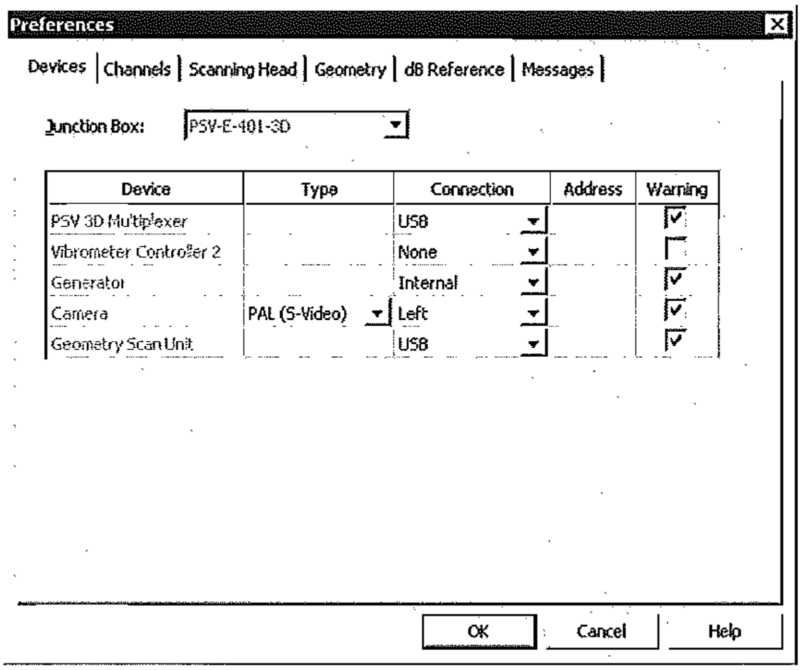


Figure 3.2: Page Devices for the PSV-3D

3.1 Devices

On the page Devices you set which measurement system and which external devices you want to control with the software.

Depending on the measurement system and equipment, the page Devices may look different.

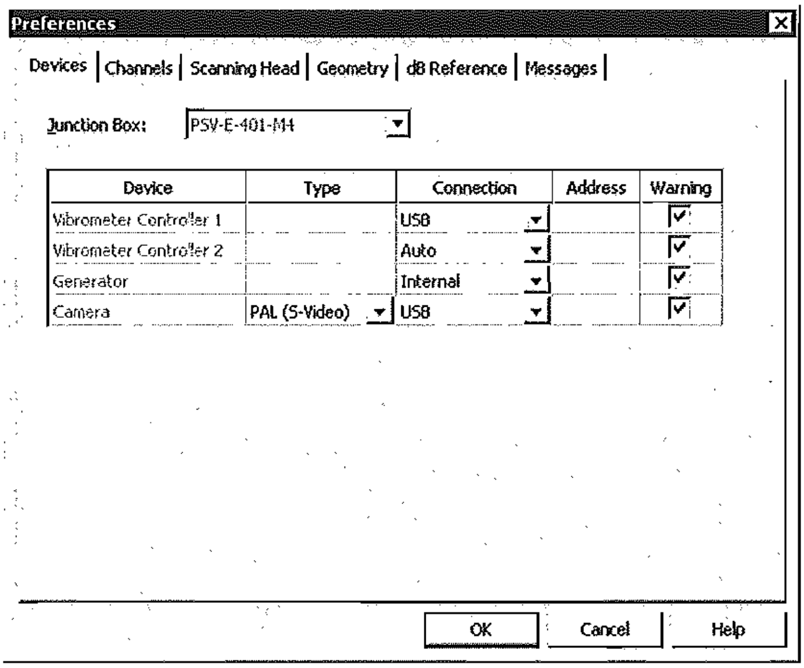


Figure 3.1: Page Devices

Junction Box: This list is only active for certain hardware configurations. Junction boxes connected via the USB interface are recognized automatically and displayed.

☞ If you have the option of changing the hardware selection, you have to log in as an administrator to change it.

To use the option VDD for MSA/MSV, you must select the junction box VDD-Z-010, VDD-Z-011, VIB-E-400-VDD, MSA-E-500 (VDD), or MSA-E-40x (VDD).

☞ OFV-5000: To be able to run the test mode automatically, the controller has to be controlled remotely via USB and has to be connected with VDD Vib Controller 1 on the page Channels (refer to SECTION 3.2).
OFV-3001: In this case it is not possible to connect up a controller which is remotely controlled. There is only a connection to the reference signal, not the vibrometer signal.

Device: Here the connected external devices are displayed.

Type: Here you select the camera type PAL or NTSC that you are using. If you are using the junction box PSV-E-401 or PSV-E-401-3D, here you have to select the camera PAL (S-Video) or NTSC (S-Video).

Connection: Here you can select which interfaces should be searched to look for external devices. For the vibrometer controllers you have to state where the devices are connected (RS-232 or GPIB). If the vibrometer controller is connected via the USB interface, it will be recognized automatically. Then you do not have to make any more settings for this controller. If you are using a generator, you can also state whether the device is integrated into the PC (internal) or whether it is an externally connected device.

Address: If you have given a fixed connection, then select the address here or carry out an automatic search for it (Auto).

Warning: If you change into acquisition mode or have changed any settings, then the software will search the PC's interfaces for external devices and initialize them. Here you mark the devices which you want a warning message issued for if the software can not find them.

☞ These warnings are not shown if under Setup > Preferences on the page Messages you have selected Errors or Show None respectively (refer also to SECTION 3.7).

Activate PSV-3D

You can operate the PSV-3D in 1D mode (PSV-3D (1D)) and in 3D mode (PSV-3D (3D)). In contrast to 3D mode, in 1D mode the signals of every scanning head are displayed and processed without transforming the coordinates. The channels measured are designated as Vibrometer Top, Vibrometer Left and Vibrometer Right.

PSV-3D in 3D mode

To activate the PSV-3D in 3D mode, select the junction box PSV-E-401-3D or PSV-E-400-3D.

☞ If you want to change the hardware selection, you have to log in as administrator.

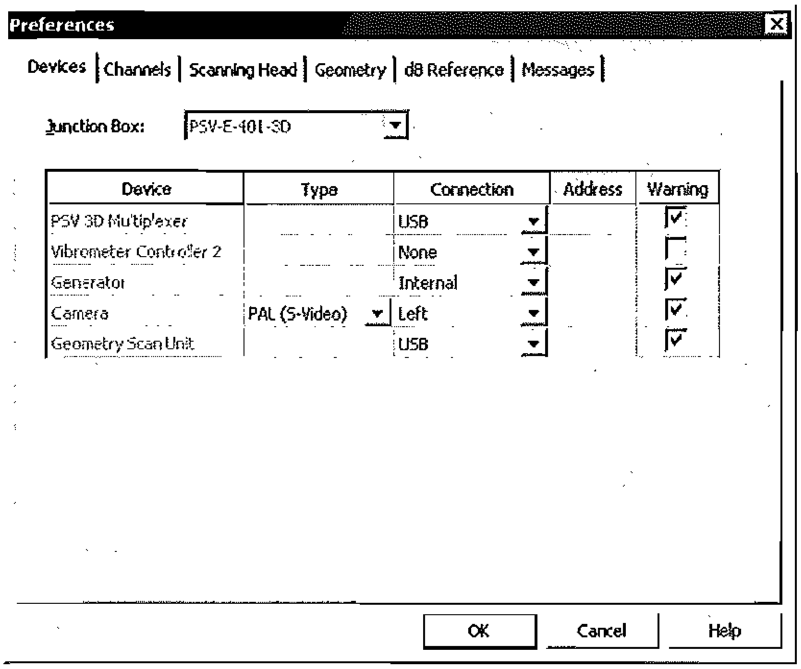


Figure 3.2: Page Devices for the PSV-3D

The first device shown to you in the list is the PSV-3D Multiplexer. This enables you to control all three controllers from the PC using the software via a single USB cable. Apart from that, under Connection you can select the video camera which you would like to use to view your object. If you have arranged the scanning heads relatively far apart, then we recommend that you select the optional video camera Center.

☞ If you are using a digital camera for PSV-3D as a center camera, select Digital as the type. If you are not using the video camera Center and the scanning heads are mounted close to each other, then the video camera Left is closest to the middle for design reasons. If you are measuring with the geometry scan unit, we recommend using the video camera Top.

You will find information on connecting up the PSV-3D in the separate hardware manual.

PSV-3D as PSV-1D

To activate PSV-3D as PSV-1D, select the junction box PSV-E-401-1D or PSV-E-400-1D. You will then only need one controller and one scanning head. Your PSV-3D will then behave like a standard PSV.

☞ The channel allocation does not match the names on the junction box (refer to SECTION 3.2).

PSV-3D in 1D mode

To activate PSV-3D in 1D mode, select the junction box PSV-E-401-3D (1D) or PSV-E-400-3D (1D). You can use 1D mode for fault diagnosis for 3D mode.

☞ In 1D mode you can make measurements with one, two or three scanning heads. You can also use up to two scanning heads as reference.

Fault diagnosis in 1D mode

If you have any misgivings about the measurement results in 3D mode being correct, you can make a 1D measurement without coordinate transformation and check the plausibility of the vibration signals in this mode. The limitations mentioned in the following apply here.

If you operate the PSV-3D with just one scanning head, then you have to deactivate the other two scanning heads (vibrometers). To do so, click A/D and display the page Channels, refer also to SECTION 3.2. Deactivate the two vibrometers that you do not want to use for making measurements.

However, you can also use the other two vibrometers to make reference measurements. To do so, click A/D and mark the vibrometers as reference channels.

☞ The Vibrometer Top can not be used as a reference channel.

Once you have identified the scanning heads as reference channels, they are not moved during scanning and can also not be controlled via the video image. Move the reference scanning heads using the icons Position in the scanning head controller. You will find more information on this in SECTION 4.1.

If the scanning heads have not been defined as reference channels, but simply as Channel, then they are moved during scanning and every scanning head supplies separate 1D information.

Special features for the MSA

If you are using the MSA-500 with the option MSAGeo, or respectively have connected an XY positioning stage to an MSA with the option Data import: Geometry (ImpGeo), then the additional devices are also shown.

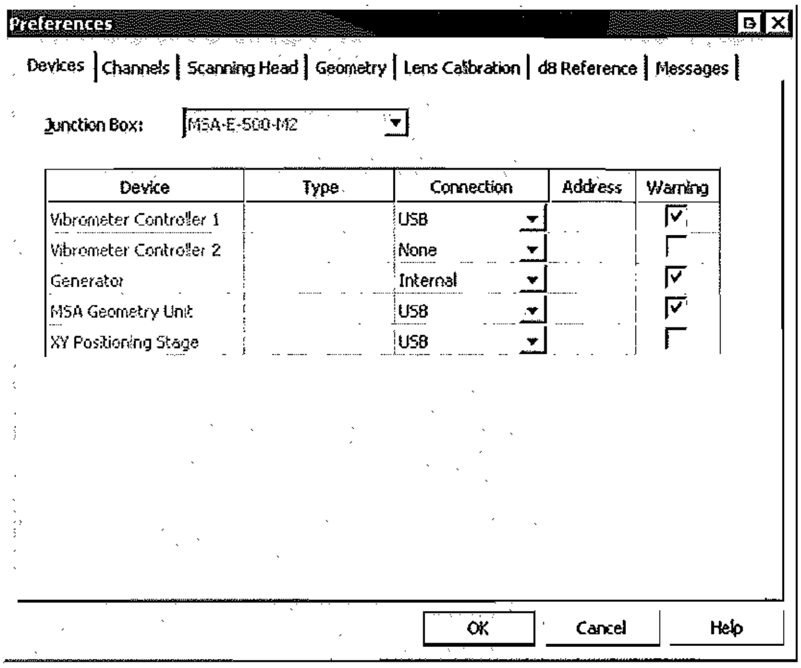


Figure 3.3: Page Devices for the MSA

With the option MSAGeo in the MSA-500 you can control the optional XY positioning stage, focus the laser beam, carry out a 3D alignment and define 3D geometries.

With the option ImpGeo in the MSA-400 or MSA-500 respectively, you can control the optional XY positioning stage, carry out a 3D alignment and import 3D geometries.

☞ As default, displaying the warning message for the XY positioning stage is not activated. Tick this box if you want a warning message to be displayed when searching for the devices.

Special features for the UHF

If you are using the UHF with the XY positioning stage, then the additional device is also shown.

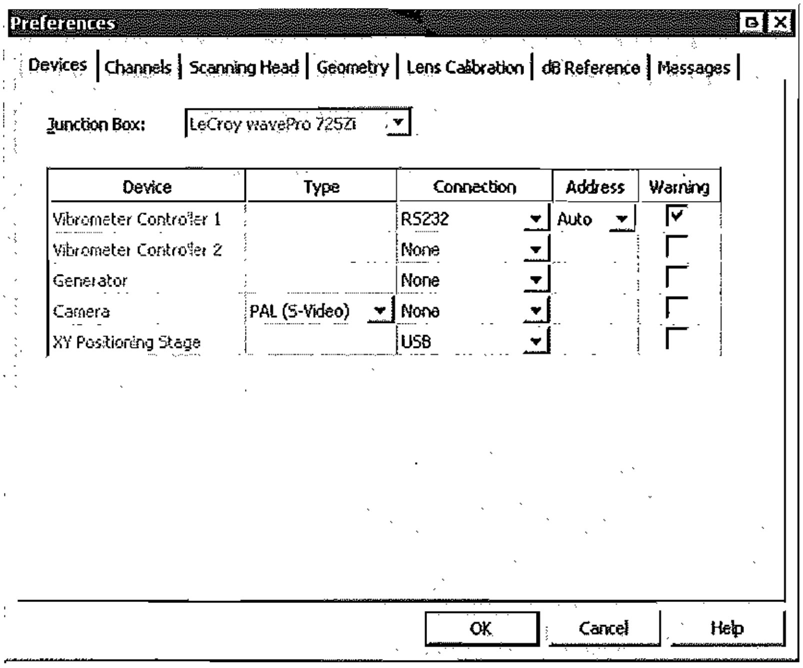


Figure 3.4: Page Devices for the UHF

Using the software, you can control the XY positioning stage and carry out a scan with the UHF.

☞ As default, displaying the warning message for the XY positioning stage is not activated. Tick this box if you want a warning message to be displayed when searching for the devices.

3.2 Channels

On the page Channels you set which channels you want to use to control Polytec vibrometers.

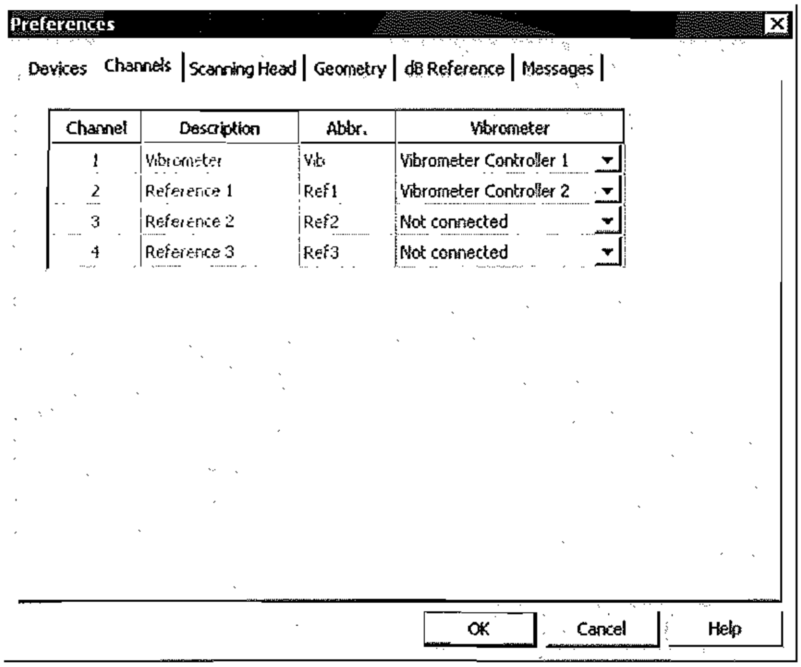


Figure 3.5: Page Channels

Channel: The number of channels displayed depends on which data acquisition board(s) you are using and which junction box has been selected on the page Devices (refer to SECTION 3.1). However, the number of channels is only updated if you close the dialog Preferences by clicking OK and then reopening it.

☞ If you want to make a measurement with the MSA/MSV using the option VDD, then you have to connect the channel with VDD Vib Controller 1 and set the appropriate junction box on the page Devices (refer to SECTION 3.1).

Description: A meaningful name for every channel is shown here.

Abbr. An abbreviated name for every channel is given here.

Vibrometer: In this column, a channel is only active if: a Polytec vibrometer is connected, the vibrometer had already been switched on before changing into acquisition mode and the correct connection has been set on the page Devices. Here you select which vibrometer provides the signal for this channel. You can use the software to control the connected vibrometers as described in SECTION 7.8.6. For certain hardware configurations and measurement modes, channels are already permanently connected.

In the following tables you will find the allocation of digital channels to the different connections from the individual junction boxes.

Channel	Junction box					
	PSV-E-401	PSV-E-401-3D (3D/1D)	PSV-E-401-1D	PSV-E-400	PSV-E-400-3D (3D/1D)	PSV-E-400-1D
1	VELO	VELO TOP	VELO TOP	VELO	VELO TOP	VELO TOP
2	REF 1	VELO LEFT	VELO LEFT	REF 1	VELO LEFT	VELO LEFT
3	REF 2	VELO RIGHT	VELO RIGHT	REF 2	VELO RIGHT	VELO RIGHT
4	REF 3	REF	REF	REF 3	REF	REF
5[1]	REF 21	REF 21	REF 21	REF 21	REF 21	REF 21
6[1]	REF 22	REF 22	REF 22	REF 22	REF 22	REF 22
7[1]	REF 23	REF 23	REF 23	REF 23	REF 23	REF 23
8[1]	REF 24	REF 24	REF 24	REF 24	REF 24	REF 24

[1] with PSV-E-408

Channel	Junction box			
	MSA-E-500	MSA-E-40x	MSV-Z-040	LeCroy wavePro (UHF)
1	VELO IN	VELO IN	VELO	CH2
2	REF IN	REF IN	REF	CH3

Channel	Junction box			
	VIB-E-220	VIB-Z-010	VIB-Z-012	VIB-Z-015	VIB-E-400-80 VIB-E-400-1000
1	VELO	SIG IN	VELO	CHANNEL 1	VELO
2	REF	REF IN	REF 1	CHANNEL 2	REF 1

Channel	Junction box			
	VIB-Z-014	VIB-Z-016	VIB-Z-017	VIB-E-400-84 VIB-E-400-1004
1	VELO	VELO	VELO	VELO
2	REF 1	REF 1	REF 1	REF 1
3	REF 2	REF 2	REF 2	REF 2
4	REF 3	REF 3	REF 3	REF 3

Channel	Junction box				
	VDD-Z-010	VDD-Z-011	VIB-E-400-VDD	MSA-E-500 (VDD)	MSA-E-40x (VDD)
1	Vibrometer signal[1]	Vibrometer signal[1]	Vibrometer signal[1]	Vibrometer signal[1]	Vibrometer signal[1]
2	REF IN	REF 1	REF 1	REF IN	REF IN

[1] The vibrometer signal is not fed in through the junction box; it is only available directly in the software (only with option VDD).

Channel	Junction box	
	PSV-Z-040-H	PSV-Z-040 -F, -U
1	VELO	VELO
2	REF 1	REF
3	REF 2	-
4	REF 3	-

With the junction boxes PSV-E-40x, PSV-E-40x-3D, VIB-Z-012, VIB-Z-016, and VIB-E-400 you can select ICP® for the reference channels and also switch the differential input for all channels on or off. You will find additional information on this in SECTION 6.2.2 under the keywords ICP and Differential Input and in your hardware manual as well.

If in addition to the junction box PSV-E-40x or PSV-E-40x-3D, you are using the junction box PSV-E-408, you can measure four additional reference channels (Reference 21 to Reference 24) using a second data acquisition board (PCI-4452 or PCI-4462).

Allocate channels for the PSV-3D

With the PSV-3D, you can only adjust settings on the page Channels if you have an additional reference (single point) vibrometer connected.

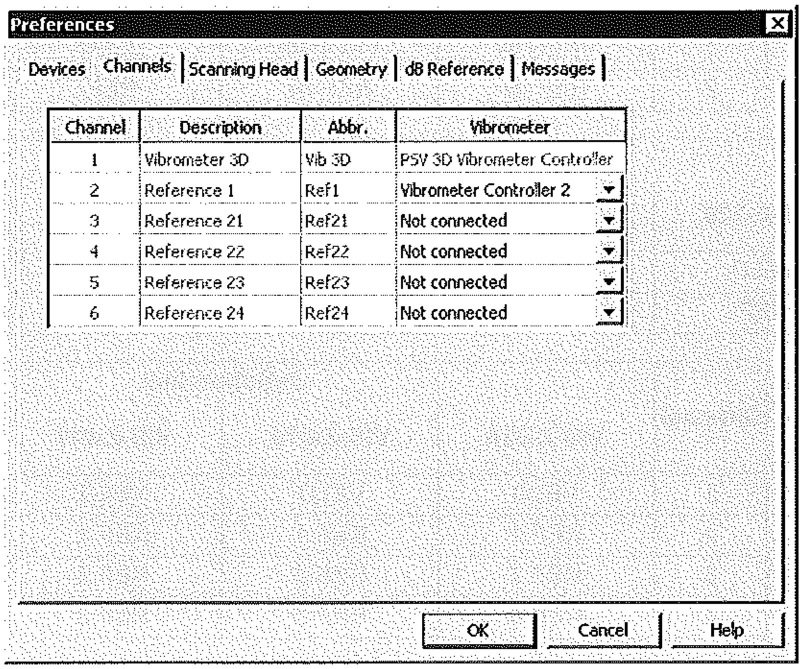


Figure 3.6: Page Channels for the PSV-3D

☞ If you want to operate the PSV-3D in 1D mode (junction box PSV-E-40x-3D (1D)), we recommend connecting the channels Vib Top, Vib Left and Vib Right with the vibrometer PSV 3D. This way you can remotely control all three controllers together.

☞ If you want to operate the PSV-3D as a pure PSV-1D (junction box PSV-E-40x-1D), then the allocation of the channels displayed does not match the names on the junction box. Please note the following allocation: Vib corresponds to VELO TOP, Ref1 corresponds to VELO LEFT, Ref2 corresponds VELO RIGHT and Ref3 corresponds to REF.

3.3 Scanning Head

You can set up the optics of the measurement system on the page Scanning Head. The settings for the PSV-1D are described in the following. Further down you will find information on the settings for the PSV-3D and special features for the MSA and UHF.

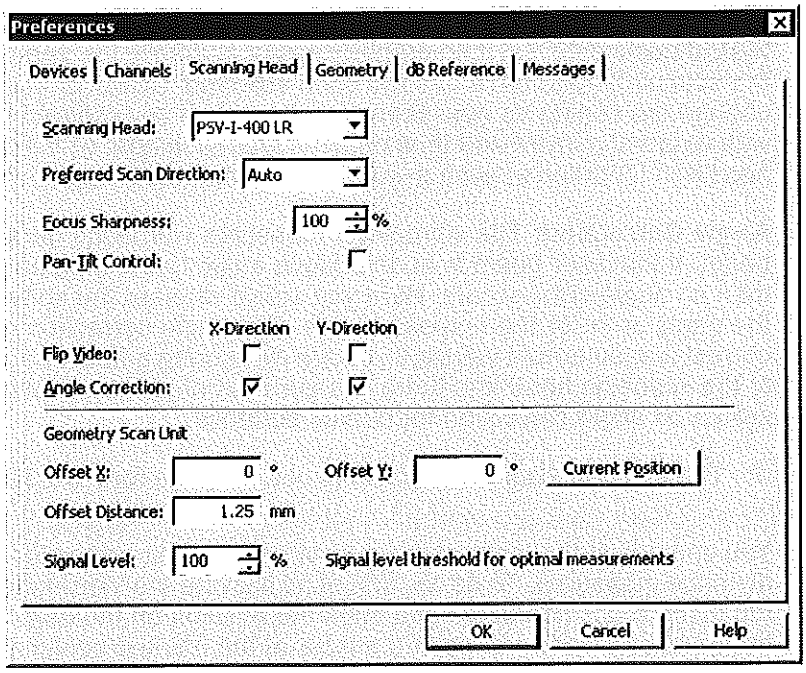


Figure 3.7: Page Scanning Head for the PSV-1D

Scanning Head: Select the scanning head of your measurement system here. The scanning head PSV-I-400 is delivered with the LR (Long Range) front lens as standard, as an option you can also have the MR (Mid Range) front lens. It is necessary to make a distinction between the two front lenses in the software to calculate the depth of focus correctly. Only PSV-200: Select the OFV-055F if your scanning head is equipped with a color camera.

Preferred Scan Direction: Here you select how the laser beam is to be moved when scanning. If the scan points are to be hit row by row, select X-Direction. If the scan points are to be hit column by column, select Y-Direction. In the latter case, the scanning time is shorter because the scanner mirror for the y-direction is smaller and thus has a shorter settling time. If you select Auto, the software independently optimizes the order in which the scan points are hit. Select Index if the scan points are to be hit in ascending order according to the index.

☞ If you have selected Index, you can individually set the order by changing the indices of the scan points (refer also to SECTION 5.4.2).

Focus Sharpness: This line only appears if you have selected the scanning head PSV-I-400 LR or MR. You can set the depth of focus here. The smaller the value you select, the less often the focus is corrected during a measurement. The standard value is 100%. However you can also set values to be greater than 100%. But please note that frequent readjustment of the focus can considerably increase the measurement time.

☞ For focus to be adjusted during the measurement, you have to select the command Focusing during Scan in the menu Scan.

Pan-Tilt Control: This line only appears if you have selected the scanning head PSV-I-400 or OFV-056 above. Tick the box if you want to control the optional pan-tilt stage using the software.

Flip Video: Here you can flip the live video image on the x- or y-axis and thus, if necessary, set it up properly again. Normally the appropriate boxes for the scanning head have already been selected. However you can also change the setting as necessary, for example if you redirect the laser beam with external mirrors and thus obtain a flipped image, or if the scanning head has been mounted in such a way that it generates a flipped image.

Angle Correction: The vibrometer measures vibrations parallel to the laser beam. If the laser beam is at an oblique angle to the measurement surface, then an angle error occurs. Here you select whether the software is to correct the angle error for the respective axis. The angle correction only provides correct measurement values if you are measuring a flat surface at right angles to the scanning head and there is a pure out-of-plane vibration. You should switch off angle correction for curved surfaces.

☞ The function Angle Correction is not available for PSV-3D.

Geometry scan unit

You can adjust the laser of the geometry scan unit and enter an offset to the distance measured. To do so, first of all activate the vibrometer laser, position the laser to position 0°/0° and mark the position on the object. Then activate the geometry laser and point the laser at the marked position.

Current Position: Click here to apply the current position of the geometry laser as angular deviation Offset X and Offset Y in the software.

Offset Distance: Here you enter the difference between the theoretical and the real beam path in the scanning head. You will find this value (Geo Offset Distance) on a label stuck to the bottom of the geometry scan unit. The value is in the region of max. ±3mm.

Signal Level: Here you enter the signal level threshold in % of full scale from which the scan points should be awarded the Geometry Status Optimal Measured. The higher the threshold is set, the less scan points will be given the status Optimal Measured.

☞ You can enter values from approx. 40% to 100%. The lower limit depends in the geometry scan unit you are using.

Arrangement of scanning heads for the PSV-3D

In addition to the setting options for the PSV-1D, with the PSV-3D you can mount the scanning heads at an angle relative to the video camera used. The software will compensate for this tilt if you move the beam with the icons Position in the scanning head control (refer to SECTION 4.1). So that the laser beams can travel in the required direction, you have to set the tilt angle for every scanning head. The respective tilt angles are given clockwise when looking in the direction of the emitted laser beam. Two configurations have already been predefined:

- Staggered horizontally 
- Star-shaped 

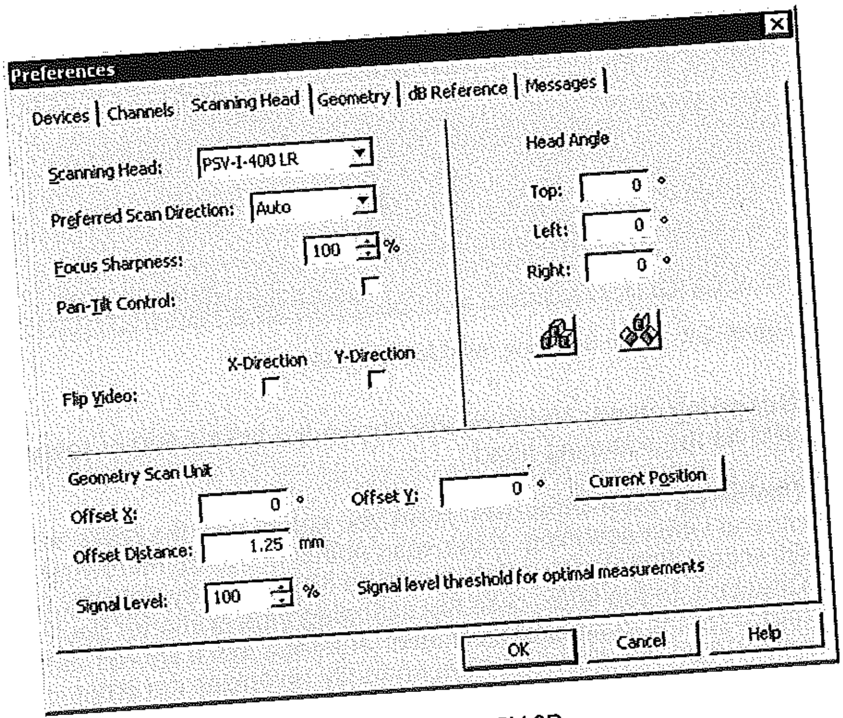


Figure 3.8: Page Scanning Head for the PSV-3D

Head Angle: Click  if you have the scanning heads mounted so that they are staggered horizontally. Click  if you have the scanning heads mounted in a star-shape. In both of these cases, the tilt angles will be entered automatically.

If you have mounted the scanning heads with a different tilt, then please enter the values yourself.

Arrangement of scanning heads for the PSV-3D

In addition to the setting options for the PSV-1D, with the PSV-3D you can mount the scanning heads at an angle relative to the video camera used. The software will compensate for this tilt if you move the beam with the icons Position in the scanning head control (refer to SECTION 4.1). So that the laser beams can travel in the required direction, you have to set the tilt angle for every scanning head. The respective tilt angles are given clockwise when looking in the direction of the emitted laser beam. Two configurations have already been predefined:

- Staggered horizontally
- Star-shaped

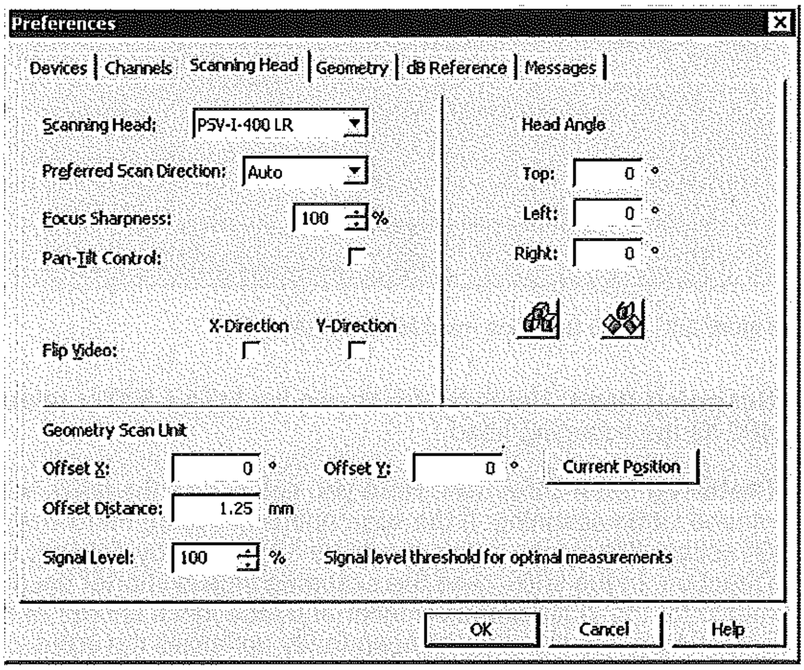


Figure 3.8: Page Scanning Head for the PSV-3D

Head Angle: Click if you have the scanning heads mounted so that they are staggered horizontally. Click if you have the scanning heads mounted in a star-shape. In both of these cases, the tilt angles will be entered automatically.

If you have mounted the scanning heads with a different tilt, then please enter the values yourself.

Flip Video: Here you can flip the live video image on the x- or y-axis and thus, if necessary, set it up properly again. Normally, the appropriate boxes for the scanning head have already been selected. However, you can also change the setting as necessary, for example if you redirect the laser beam with external mirrors and thus obtain a flipped image, or if the scanning head has been mounted in such a way that it generates a flipped image.

Special features for the UHF

If you are using the UHF, you have restricted settings on the page Scanning Head.

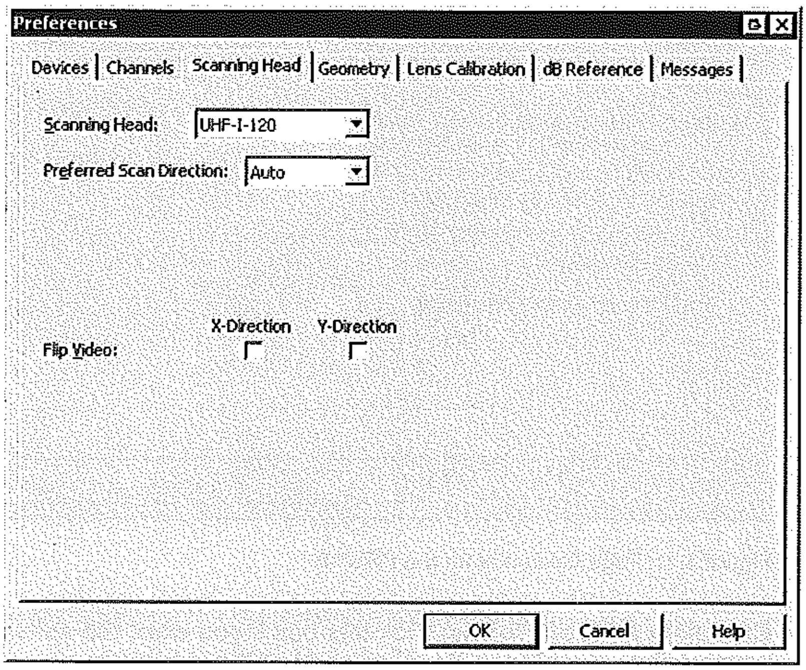


Figure 3.10: Page Scanning Head for the UHF

Scanning Head: Here you are shown the UHF-I-120 as the scanning head.

Preferred Scan Direction: Here you select how the XY positioning stage is to be moved when scanning. If the scan points are to be hit row by row, select X-Direction. If the scan points are to be hit column by column, select Y-Direction. If you select Auto, the software independently optimizes the order in which the scan points are hit. Select Index, if the scan points are to be hit in ascending order according to the index.

☞ If you have selected Index, you can individually set the order by changing the indices of the scan points (refer also to SECTION 5.4.2).

Flip Video: Here you can flip the live video image on the x- or y-axis and thus, if necessary, set it up properly again. Normally, the appropriate boxes for the scanning head have already been selected. However, you can also change the setting as necessary, for example if you redirect the laser beam with external mirrors and thus obtain a flipped image, or if the scanning head has been mounted in such a way that it generates a flipped image.

3.4 Geometry

On the page Geometry you can get the software to calculate hidden points and have the focus values calculated automatically using the focal length of the lens in the scanning head.

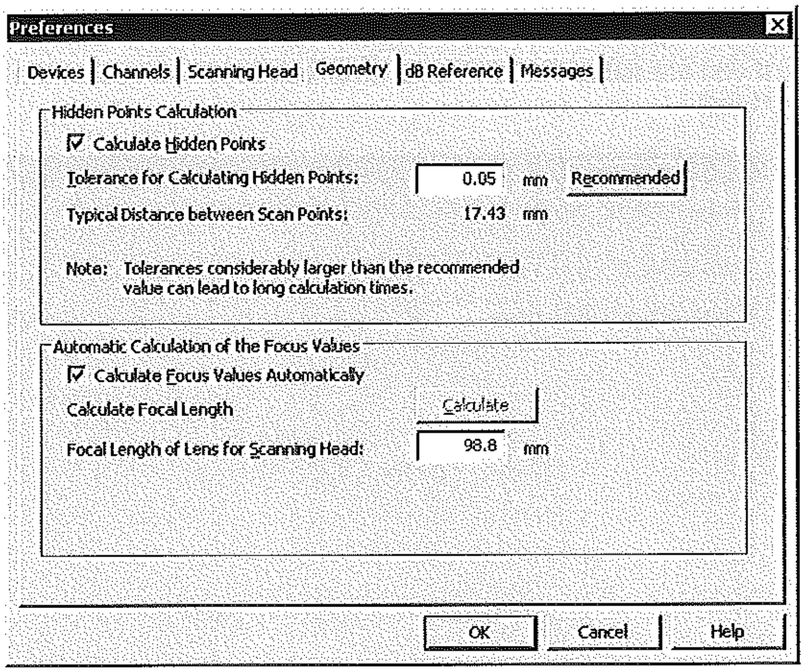


Figure 3.11: Page Geometry for the PSV-1D

Hidden Points Calculation

Calculate Hidden Points: Tick this box if you want the software to calculate which points are hidden by other parts of the geometry.

☞ If you are working with a large number of scan points, this calculation can take some time. In this case, you can deactivate the calculation here.

☞ Calculation of the hidden points is not available for the UHF.

Tolerance for Calculating Hidden Points: Here you can enter a tolerance value for recognizing hidden points. The tolerance value is used to compensate for the deviations between the defined geometry and the actual shape of the object under investigation. Scan points which can only be reached by the laser beam if they pass the geometry at a distance smaller than the tolerance value, are marked as Hidden.

Recommended: Click here and the software will give you a recommendation for the tolerance value, the result of which depends on the typical distance between scan points (approx. half).

Typical Distance between Scan Points: Here the software shows the typical value for the distance between two scan points.

Automatic Calculation of the Focus Values

Calculate Focus Values Automatically: Tick this check box if you want to have all focus values calculated automatically on the basis of the focal length of the lens in the scanning head. If you do not know the focal length of the lens, then you will have to calculate it. To do so, start a scan with the function Assign Focus Fast or Assign Focus Best (refer also to SECTION 5.6.2). Every scan point is assigned a focus value. Then click Calculate.

☞ Automatic calculation of the focus values is not available for the MSA/ MSV and the UHF.

Calculate: Click here if you want to calculate the focal length of the lens in the scanning head from the focus values identified. The focal length will then be entered automatically.

Focal Length of Lens for Scanning Head: If the focal length of the lens in the scanning head is known, you can also enter the value directly.

☞ For the PSV-3D the focal length of the lenses for all three scanning heads (Top, Left and Right) are entered here.

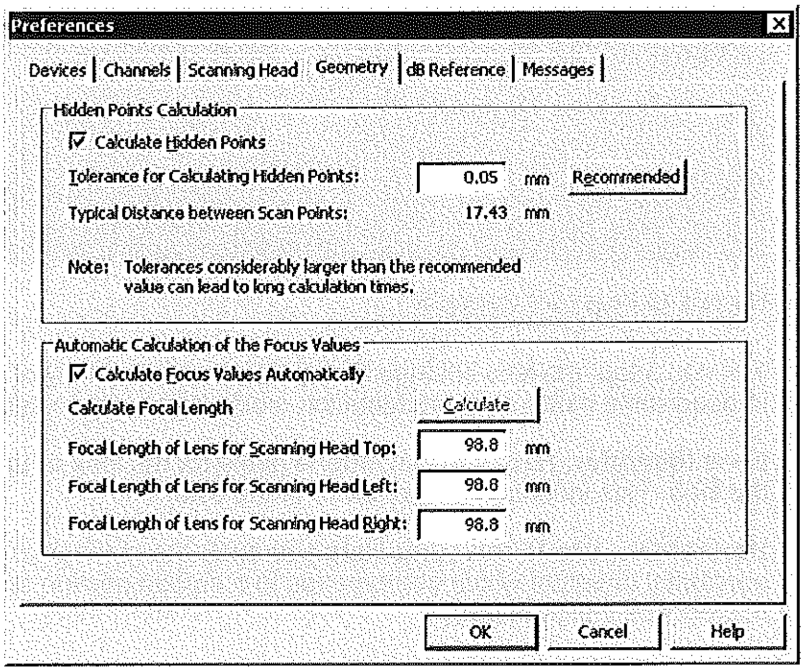


Figure 3.12: Page Geometry for the PSV-3D

3.5 Lens Calibration (only MSA and UHF)

On the page Lens Calibration you enter the name or the type and resolution of the lens used. The dialog already contains some lenses with the respective values as default. You can overwrite these entries and add any number of other lenses.

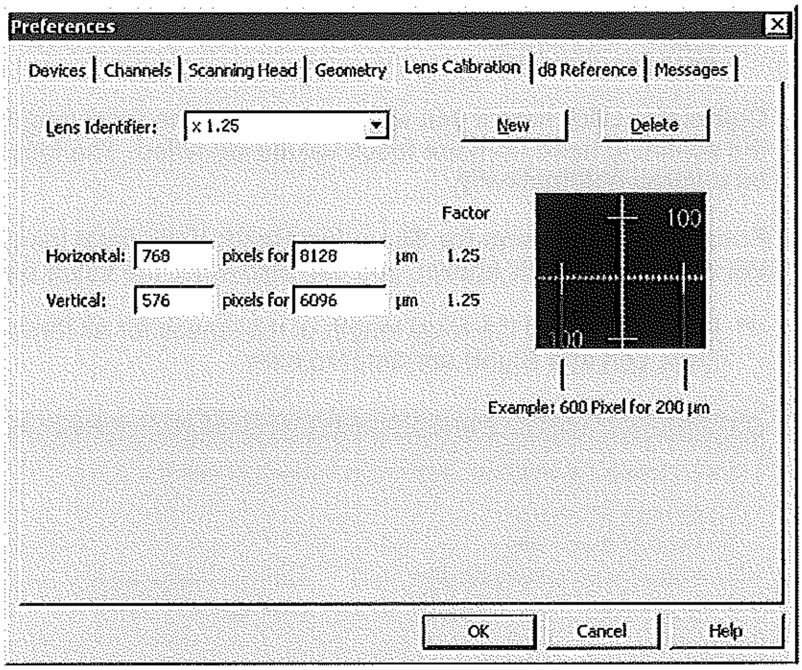


Figure 3.13: Page Lens Calibration

Adapt lens settings

You can adapt the lens settings at any time, independently of whether you are in acquisition mode or in presentation mode (refer also to SECTION 2.5).

Lens Identifier: Here you can enter a name for the lens or the zoom factor of the lens. This identifier is also saved in the scan.

Horizontal...pixels for...µm: Here you enter the number of pixels in a horizontal direction which corresponds to a certain section length your microscope image in µm.

Vertical...pixels for...µm: Here you enter the number of pixels in a vertical direction which corresponds to a certain section length your microscope image in µm.

Factor: Here you will be shown the magnification factor of the lens depending on your entries. This value corresponds with that printed on the lens.

☞ Please pay attention that with the UHF the magnification of the lens is decreased by the factor 4. You can only see the correct magnification factor in the dialog Preferences on the page Lens Calibration.

Add lenses

You can only add further lenses for data acquisition if you are in acquisition mode.

New: Click here to add a new lens to the list Lens Identifier. The new lens is given the same name as the last one selected, supplemented by a consecutive number, e.g. x20 (2). The number of pixels and the distance (horizontal and vertical) of the last lens selected are also applied. Overwrite the entries with the appropriate values.

Delete lenses

Delete: To delete a lens, select it in the list Lens Identifier and click here. Then, if necessary, select another lens and click OK.

Determine pixels and distance

To determine the pixels and the distance for the lens used, proceed as follows:

1. Exit the PSV software.
2. Place the stage micrometer supplied under the microscope lens and use the keys on the junction box MSA-E-500 or MSA-E-40x or resp. on the controller UHF-E-120 to switch the illumination on.
3. Start the BCAMViewer. To do so, double-click the icon  on the desktop. The BCAMViewer window appears.

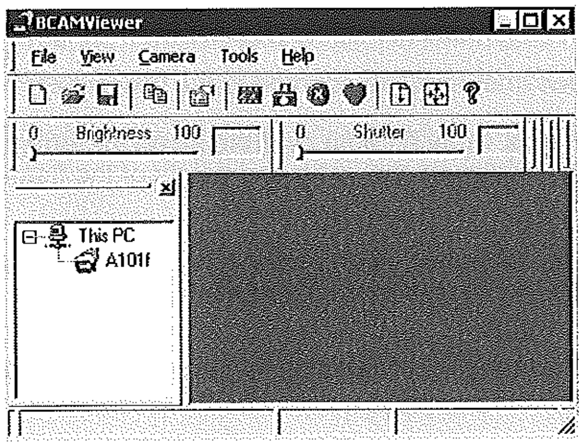


Figure 3.14: Example of the BCAMViewer window

4. Double-click the name of the camera, e.g. A101f in the navigation area on the left side of the window.
5. Maximize the window and click . The video image is displayed. If you see a gray video image instead of the stage micrometer, you have to deactivate the trigger as follows.

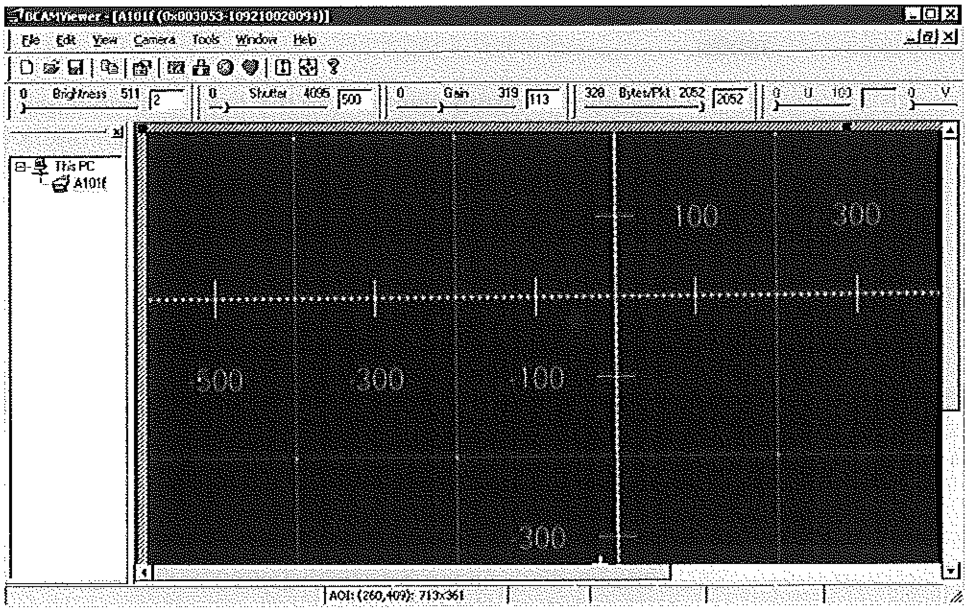


Figure 3.15: Video image with stage micrometer

6. To do so, select View > Properties. The dialog Properties appears.
7. Here display the page Trigger and deactivate the check box Use Trigger.
8. If the video image does not fill the BCAMViewer window completely, click [icon]. The video image will be adapted to the window section.
9. Using the mouse, draw a frame over the stage micrometer. In the status bar of the BCAMViewer, the width and height of the frame is shown in pixels.

If you start the BCAMViewer again, you will be shown the last frame set. To delete an existing frame, proceed as follows:

10. Click [icon]. The frame is activated and maximized, i.e. it encloses the whole video image.
11. Now, using the mouse, draw the required frame.
12. On the stage micrometer, read the width and the height of the frame in µm and in the status bar, read the width and the height of the frame in pixels.
13. Close the BCAMViewer and start the PSV software.
14. Go into acquisition mode, open the dialog Preferences and display the page Lens Calibration.
15. Under Horizontal enter the width in pixels and in µm and under Vertical the height in pixels and in µm.

☞ Make sure that you switch the microscope illumination off again before making a measurement.

3.6 dB Reference

On the page dB Reference you can define dB = 0. You can thus directly follow an online measurement with a certain dB reference.

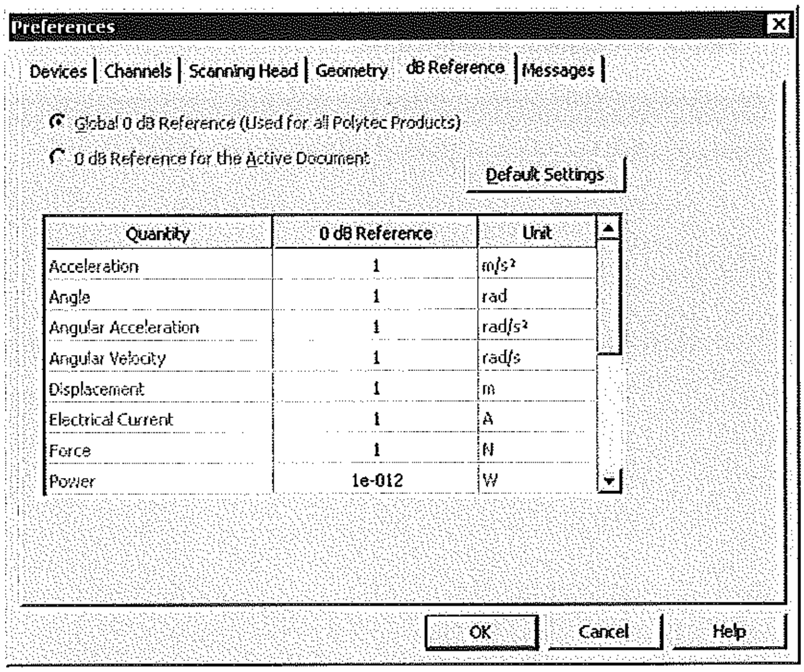


Figure 3.16: Page dB Reference

☞ Changes you make here only have an effect on the global 0dB reference (applies to all Polytec products). If you want to change the local 0dB reference for the active document, you have to open the page in presentation mode. See also SECTION 8.4 under 0dB Reference on this.

Default Settings: Click here if you want to recover the original settings for the 0dB reference.

Quantity: All available physical quantities are shown here.

0dB Reference: Here you can define the factor for the respective unit.

Unit: The unit for the respective physical quantity is shown here.

Example:

Quantity	**0dB Reference**	**Unit**
Displacement	2e-3	m

The 0dB reference for the quantity Displacement is 2mm.

☞ If you want to evaluate combined signals (e.g. Vib & Ref1, see also SECTION 8.4 on this), define the 0dB reference for both quantities.

3.7 Messages

On the page Messages you select which system messages you would like to have displayed.

☞ Message windows which contain queries or which advise you of faulty input will appear in any case.

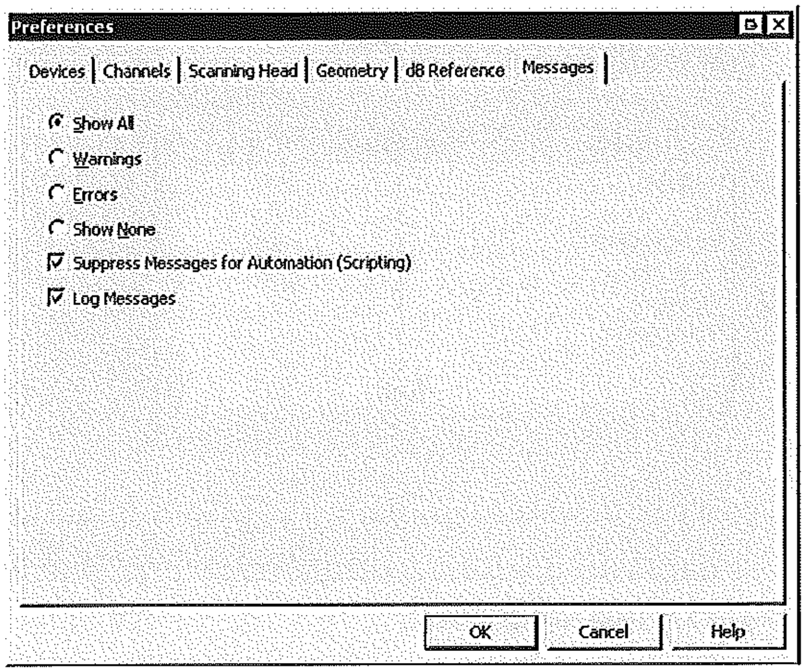


Figure 3.17: Page Messages

Show All: Click here if you would like to see all messages (notes, errors and warnings).

Warnings: Click here if you would like to be informed of warnings and errors.

Errors: Click here if you would only like to see error messages.

Show None: Click here if you do not want to receive any system message.

Suppress Messages for Automation (Scripting): Tick this box if you want to suppress messages during an automatic activity (Scripting). Otherwise it is possible that the activity of macros is disrupted by these messages.

Log Messages: Tick this box is you want to log all messages. You will find the log file on the Control Panel. To do so, select Start > Settings > Control Panel and double-click Management and then Display Events. The window for the Event Viewer appears. Under Polytec you will find a log of the messages.

You can export the list. To do so, click or select Action > Export List. The dialog Export List appears. Navigate to the required saving location, enter the file name and click Save.

4 Setting the Optics

Depending on which measurement system model you have, you can control certain optical functions:

Controlling the Hardware, refer to SECTION 4.1

Automatically Focusing the Laser Beam, refer to SECTION 4.2

Image Settings of the Live Video Image, refer to SECTION 4.3. Here, you adjust contrast, brightness and color of the video image.

Performing 2D Alignment, refer to SECTION 4.4. Here, the positions on the live video image have to be aligned with the position of the laser beam on the measurement plane.

Performing 3D Alignment, refer to SECTION 4.5. Here, the position and alignment of the scanning head (PSV/MSA) or scanning heads (PSV-3D) in the coordinate system of the object are determined.

You will find further information on achieving successful 3D alignment in SECTION 4.6.

4.1 Controlling the Hardware

You can control certain functions of the hardware as described in SECTION 4.1.1 and SECTION 4.1.2.

For the PSV-400, PSV-300 and the PSV-400-3D, you can use the software to control all the optics and the optional pan-tilt stage.

For the MSA-500, MSA-400 or MSV-400 with the sensor head OFV-551/-552, you can use the software to position the laser beam and also remotely control the beam shutter and the optional dimmer on the sensor head. If you are using the MSA with the optional XY positioning stage, you can control it using the software. You set the other functions using the hardware. See your hardware manual on this.

For the UHF-120, you can use the software to attenuate the laser beam and also remotely control the XY positioning stage. You set the other functions using the hardware. See your hardware manual on this.

For the MSV-/MMA-300 with the sensor head OFV-511/-512, you can only position the laser beam with the software. You set the other functions using the hardware. See your hardware manual on this.

For the PSV-200 you can only use the software to focus and position the laser beam. You control the video camera and the optional pan-tilt stage with the video box. See your PSV-200 manual on this.

☞ You can remotely control the connected vibrometer controller. To do so, proceed as described in SECTION 6.2.8 or use the range changer in the status bar.

4.1.1 Controlling the Optics with the Software

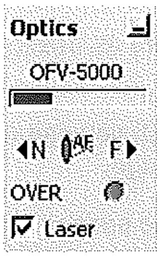
To control the optics with the software, proceed as follows:

1. Go into acquisition mode. To do so, click or select View > Acquisition.
2. If you do not see the scanning head control in the application window, then click to display it. You can also select View > Scanning Head.
3. Only scanning head MSV, MSA-I-500 and MSA-I-400: From the list Lens, select the magnification which your microscope is set at.

☞ If you can not see the list Lens in the scanning head control, then first of all set up the software for your measurement system. See CHAPTER 3 on this.

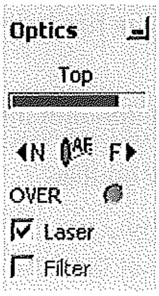
4. If necessary, maximize the video window. To do so, in the title bar of the video window on the right, click .
5. If necessary, adjust the image settings of the live video image. See SECTION 4.3 on this.
6. Using the icons in the scanning head control, you can now work as described in the following.

Focus the laser beam

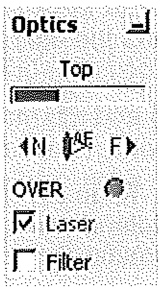


Focus the laser beam with the icons N (close-up) and F (infinity). With the PSV-400 you can also focus the laser beam automatically with the icon AF. You will find more information on this in SECTION 4.2. Above the icons you will see the optical signal level shown as a bar. This makes manual focusing easier. The LED OVER shows when the set measurement range is exceeded. In this case it lights up red. If it lights up permanently, then you have to select the next highest measurement range.

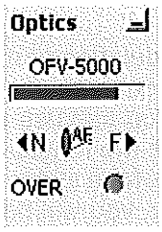
Switch the laser beam on or off



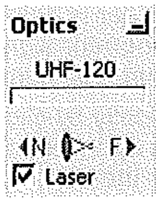
If you are using junction box PSV-E-401, PSV-E-400, PSV-E-401-3D or PSV-E-400-3D, you will see the box Laser for every scanning head. Click the boxes to switch the respective laser on or off.



If you are using a scanning head with the geometry scan unit and switch to the geometry laser, then the box Laser for the scanning head Top is not active. In this case it is not the optical signal level of the vibrometer controller that is shown, but the signal level of the geometry scan unit. If the geometry scan unit receives too much light, the LED OVER lights up red. You can switch on a filter to weaken the intensity of the laser. To do so, mark the box Filter (refer also to SECTION 5.5). If there is not enough light available, the signal level display disappears. This means you can tell whether your measurements will provide an acceptable result. To display the signal level, the geometry scan unit has to continuously determine the lighting conditions. This is why the laser beam blinks approx. every 2 seconds.

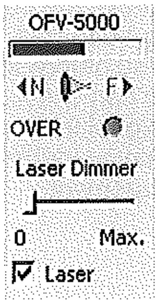


If an additional vibrometer controller is connected and active, then another field is shown in the scanning head control. As this vibrometer controller is not connected up to the system via the junction box, you can not switch the laser beam on and off here. However, the display for signal level, overrun of the measurement range as well as focusing the laser beam are available to you as described above.



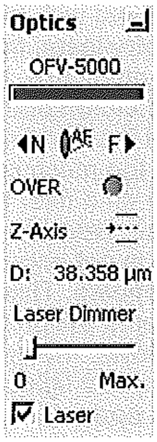
If you are making measurements using the UHF-120, you will see the box Laser for the sensor head. Click the box (refer to figure) to switch the laser to full power. If you start a measurement, the laser will automatically be switched to full power. If the measurement is finished, the laser will automatically be attenuated again. With the UHF, the optical signal level can not be shown as a bar. For optimizing the signal level, you have to monitor the modulation amplitude of the vibrometer channel (CH2) on the oscilloscope.

Dim the laser beam (as an option)



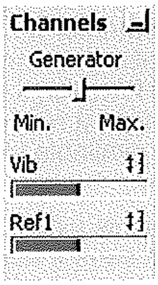
If you are using the junction box MSA-E-500 with the scanning head MSA-I-500 or the junction box MSV-E-40x with the scanning head MSA-I-400, you can control the beam shutter and use it to switch the laser on and off. To do so, click the box Laser. You can also switch the laser beam on or off directly by pressing the key LASER on the sensor head. See the manual of the sensor head on this as well. Apart from that, in the scanning head control, the slider Laser Dimmer is shown as an option. By moving this slider with the mouse in the direction Max. you can reduce the light intensity of the laser beam.

Focus the MSA laser beam (as an option only for MSA-500)

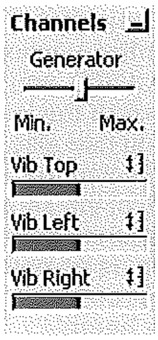


If you are using the junction box MSA-E-500 with the scanning head MSA-I-500 and the option MSAGeo, you can focus the laser beam. Focus the laser beam manually with the icons (close-up) and (infinity). In doing so, you travel up or down the z-axis. You can position the z-axis directly at zero position. To do so, click . The z-axis is then positioned in the middle of your range of travel. As an option, you can also automatically focus the laser beam using the icon . Here, you automatically travel along the z-axis and stop at the position at which the signal level is highest. The position D of the z-axis is displayed under the icon (0...250 µm). Read at the top under Dim the laser beam how to switch the laser on or off or how to dim the laser beam.

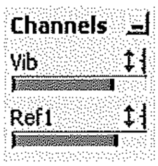
Show channels



Here you can watch the modulation of the active channels (Vib, Ref1), for example as soon as you have started a continuous measurement. You can use the slider Generator to directly change the magnitude of the generator signal. The scale of the slider is not linear. If you point the mouse at the slider, you will be shown the value of the amplitude on a yellow background. The minimum or maximum amplitude of the slider is determined by the value you entered for the generator signal (refer to SECTION 6.2.9). Apart from that, you can modulate individual channels automatically by clicking for the corresponding channel. This optimizes the input range of the data acquisition board or the sensitivity range of the vibrometer controller respectively. You can modulate all channels together automatically by clicking while holding the shift key pressed.

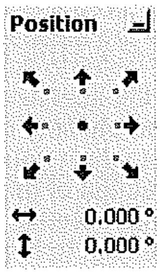


If you are using the PSV-400-3D, the channel is shown separately for each scanning head (Vib Top, Vib Left, Vib Right). Modulation is displayed before the coordinates are transformed. This is why you can check the cabling with the aid of this display. If the signal from one of the scanning heads is missing, then the display for this channel will be at zero at the start of the measurement.



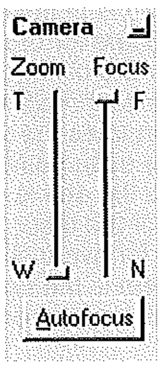
If you are using the UHF, you can only watch the modulation of the active channels (Vib, Ref1). Controlling the generator signal is not available.

Position the laser beam



You move the laser beam with the icons Position. To do so, click the icon for the direction required. If you click •, the laser beam is positioned in such a way that it is emitted at right angles to the front panel of the scanning head (position 0; 0).
Under the icons you will see the position of the laser beam in degrees related to the horizontal and vertical axis. With the MSA/MSV system, the position is shown as a percentage of the mirror deflection. At 100% the laser beam is at the far right/at the top.

Zoom the video camera

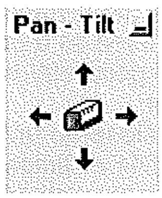


You zoom the video camera with the slider Zoom. Using the mouse you can roughly set the slider. If the slider is active, you can fine-tune it with the arrow keys ↑ and ↓. (To activate the slider, click it.)

Focus the video camera

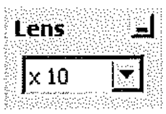
You focus the video camera with the slider Focus. Using the mouse you can roughly set the slider. If the slider is active, you can fine-tune it with the arrow keys ↑ and ↓. (To activate the slider, click it.)
You can also focus automatically. To do so, click Autofocus. Automatic focusing can take several seconds during which the software is inactive.

Pan-tilt stage (as an option)



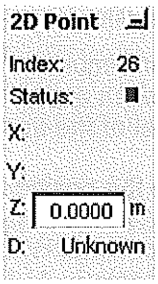
You control the motorized pan-tilt stage with the icons Pan-Tilt. If you can not see the icons in the scanning head control, then first of all activate the pan-tilt stage for the software. See SECTION 3.3 on this. To pan the scanning head, click ← or →. To tilt the scanning head, click ↑ or ↓.

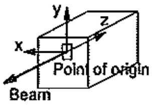
Set the zoom factor for the microscope



If you are using the scanning head MSA-I-500, MSA-I-400, MSV, or UHF-I-120, you select the zoom factor set on the microscope here. The software will calculate the coordinates of the scan points from the zoom factor set and the position of the scan points on the video image. Please pay attention that with the UHF the magnification of the lens is decreased by the factor 4. You can only see the correct magnification factor in the dialog Preferences on the page Lens Calibration.

Enter coordinates of axes

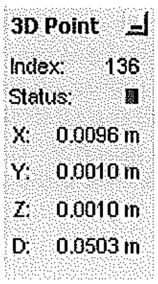




The element 2D Point is displayed if there is 2D geometry. Right at the top, the Index of the selected scan point is shown, below that its Status (refer to SECTION 7.3 as well). Enter the distance between the scanning head and the measurement object in the empty field and press Enter. The one of the three axes for which you can define the distance depends on the direction of the vibrometer channel in the dialog Acquisition Settings (refer toSECTION 6.2.2). The figures next to this apply to the direction +Z.
As the axis which shows the distance of the measurement object from the scanning head is in the opposite direction to the laser beam, the coordinate for the object always has the inverse sign. If you enter the distance between the measurement object and the scanning head as z-coordinate, the software calculates the x- and y-coordinates of the respective scan point under the assumption that the object is flat and is positioned vertically to the 0° direction of the laser beam. The z-coordinate is thus the same for every scan point. The origin of the coordinate system is the point at which the laser beam is emitted in 0° direction from the front of the scanning head.

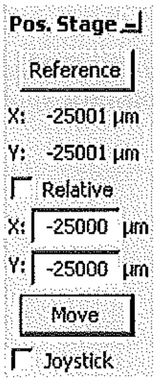
☞ The coordinates which show the distance of the object from the scanning head are used as a preset for the object distance when exporting the geometry in Universal File format and ME'Scope format.
For measurements with the close-up unit PSV-A-410 or OFV-056-C, you have to add 41 millimeters to the stand-off distance. This corresponds to the optical path length inside the close-up unit (refer also to SECTION 10.2.3 and SECTION 10.2.4).

3D Point



The element 3D Point is displayed if there is 3D geometry. Right at the top, the Index of the selected scan point is displayed. Below that, the coordinates (X, Y, Z) of the scan point are displayed. The coordinate system used here is the one which you determined with the 3D alignment (refer to SECTION 4.5).
The software calculates the distance D, i.e. the distance between the selected scan point and the point at which the laser beam in 0° direction intersects the plane of the front of the scanning head. For the PSV-3D, the distance to the scanning head Top is always given.

XY positioning stage (only MSA and UHF)



If you are using the MSA-500 with the option MSAGeo or the MSA-400 or MSA-500 with the option Data import: Geometry (ImpGeo) and the optional XY positioning stage, you can control this with the software. Controlling the XY positioning stage is also available for the UHF.
Before you can use the XY positioning stage for a measurement, you have to carry out a reference run. To do so, click Reference. This travels the axes of the XY positioning stage to the limit switches and then back to the origin (0/0). Below that, the absolute position (X, Y) is displayed. For the UHF applies: If you have not carried out the reference run, it will be automatically carried out first when you start a scan.
To move the XY positioning stage, enter the required position in x- and y-direction and click Move. Tick the box Relative if you want to move from the current position by an offset. Tick the box Joystick if you want to control the XY positioning stage with the help of the optional joystick. See the manual of the XY positioning stage on this as well.

☞ You can move the XY positioning stage using your mouse.

To do so, click in the video window and move the positioning stage in the required direction while pressing the left mouse button. Hold the shift key pressed and the positioning stage will only move in the respective main direction of movement. Zoom in on the video window to be able to move the XY positioning stage more precisely (refer to SECTION 2.6.8).

4.1.2 Controlling the Optics with the PSV-A-PDA

To control the optics with the optional PDA, start the PDA as described in SECTION 2.9.1. The user interface of the PDA software appears.

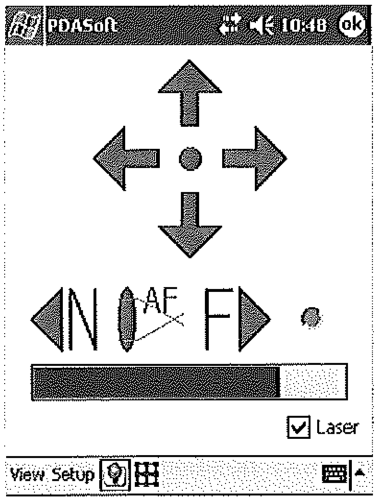


Figure 4.1: User interface of the PDA software

Position the laser beam

Move the laser beam with the icons ↓, ↑, ← and →. To do so, touch the icon for the direction required. If you touch ●, the laser beam is positioned in such a way that it is emitted at right angles to the front of the scanning head (position 0; 0).

☞ You can also use the 5-Way Navigation button on the PDA to position the laser beam. To do so, press the button for the corresponding direction.

Focus the laser beam manually (PSV-1D)

Focus the laser beam manually with the icons ◀N (close-up) and F▶ (infinity). Below the icons you will see the optical signal level shown as a bar. This makes manual focusing easier. The signal level displayed is identical to that in the software and on the scanning head. The LED next to the icons shows when the set measurement range is exceeded. In this case it lights up red. If it lights up permanently, then you have to select the next highest measurement range.

Focus the laser beam automatically

With the PSV-400 you can also focus the laser beam automatically with the icon AF. See SECTION 4.2 on this.

Switch the laser on and off

You can switch the laser on or off in the scanning head by ticking or deactivating the box Laser.

4.2 Automatically Focusing the Laser Beam

With the PSV-400 you can automatically focus the laser beam. There are two ways to do so:

- Focusing with the Software, refer to SECTION 4.2.1
- Focusing with the PDA (as an Option), refer to SECTION 4.2.2

4.2.1 Focusing with the Software

PSV

To automatically focus the laser beam with the software, click in the scanning head control.

☞ Automatic focusing can take several seconds, during which the software is inactive.
If the laser is nearly optimal focused, you can automatically focus significantly faster. To do so, hold the control key pressed and click . The software only searches for the optimal focus in a limited range. Faster automatically focusing is only available from a certain firmware version of the vibrometer controller. Please contact Polytec on this.

PSV-3D

If you are making a measurement with the PSV-3D, hold the shift key pressed while clicking . This allows all three laser beams to be focused at the same time.

☞ If you have switched the lasers off, i.e. the check boxes Laser in the scanning head control are deactivated, the software will automatically switch all lasers on as soon as you click .

4.2.2 Focusing with the PSV-A-PDA (as an Option)

PSV

Automatically focus the laser beam with the PDA by touching the icon .

☞ Automatic focusing can take several seconds during which the software is inactive.

PSV-3D

If you are making a measurement with the PSV-3D, you can select the scanning heads and focus them individually automatically.

4.3 Image Settings of the Live Video Image (2D View)

You adjust the image settings of the live video image in the dialog Display Properties on the pages:

- General, refer to SECTION 4.3.1 and
- Video, refer to SECTION 4.3.2.

To open the dialog, double-click the live video image. You can also click the live video image with the right mouse button and then select Video Properties in the context menu.

You can also activate the video window (to do so, click it) and then select Scan > Properties. Then display the appropriate page.

☞ Depending on the type of measurement and the geometry, not all settings options are shown in the dialog.

4.3.1 General

On the page General you set up the view of the video window on the screen.

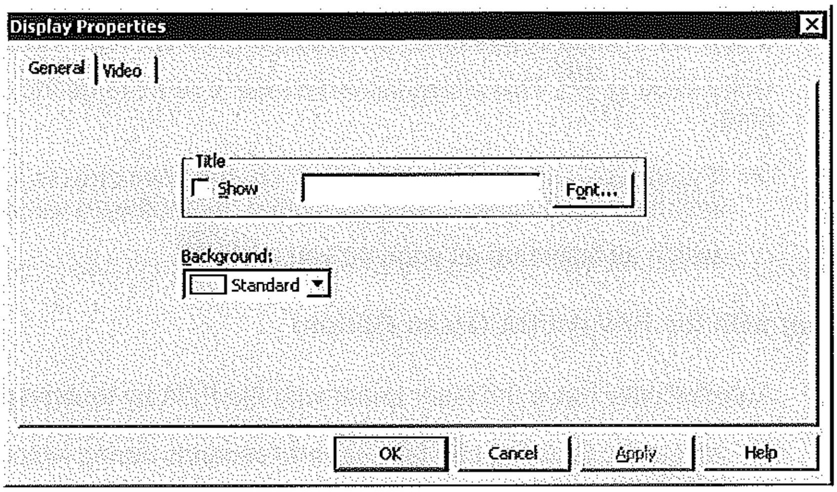


Figure 4.2: Page General

Title **Show:** If you would like to display a title above the video window, tick the box. You enter the title on the right.

Font: Click here to format the title. The dialog Font appears.

Background Here you select the background color for the video window.

4.3.2 Video

On the page Video you adjust the camera settings.

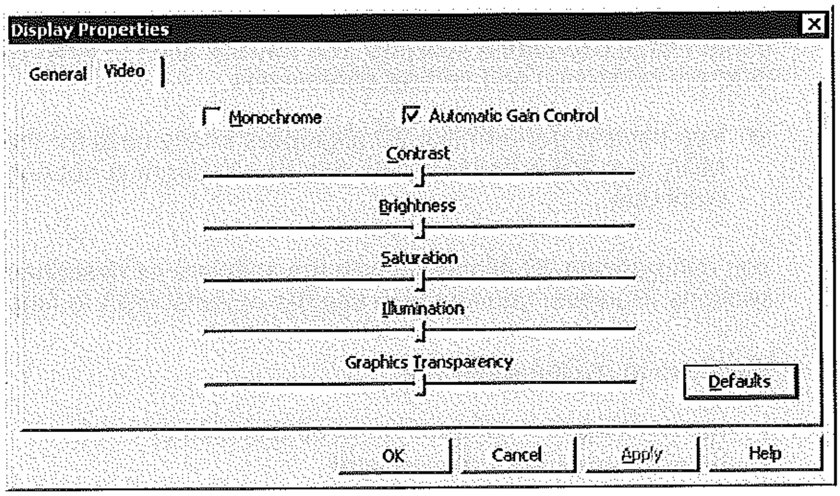


Figure 4.3: Page Video

Monochrome: Here you can change color images to black and white.This is recommended for measurements with the optional close-up unit PSV-A-410 or OFV-056-C, as it is equipped with a red filter.

Automatic Gain Control: Deactivate this box if you want to switch the automatic gain control for the video camera off again. This function is only available to you with analog, controllable video cameras (e.g. PSV-I-400 or VCT-072 H).

Contrast: Here you set the contrast of the live video image.

Brightness: Here you set the brightness of the live video image.

Saturation: For color images you set the color saturation here (not for MSA/ MSV systems).

Illumination: This slider only appears for MSA/MSV systems and for the UHF. You can adjust the brightness of the illumination here. See your hardware manual on this as well.

Graphics Transparency: Here you adjust the transparency of all inserted graphic elements (e.g. scan points, alignment points, crosshair, signal level).

☞ Maybe, this function is not available to you depending on the configuration of your system.

Defaults: Click here to load the default settings for the live video image.

4.4 Performing 2D Alignment

To define scan points on the live video image and to move the laser beam using the mouse, you have to align the positions on the live video image with the position of the laser on the measurement plane. As you are aligning two-dimensional coordinate systems, you have to align at least two points with different horizontal and vertical coordinates.

☞ You have to perform this 2D alignment in any case for the PSV, PSV-3D, MSA, and MSV. For the UHF, the 2D alignment is not necessary and not workable.

How?

You can perform 2D alignment with the software as described in the following sections. However you can also use the optional PDA to help you.

When?

You have to realign when you

- are working at a different stand-off distance or
- have zoomed the video camera.

Tips

The following tips make it easier to align:

- The more points you align, the more precisely the software positions the laser beam.
- Distribute the alignment points evenly over the whole measurement surface. If, for example, you want to scan a rectangular surface, it would make sense to choose four alignment points near the corners.
- Align those points which you want to position precisely when scanning.
- To increase the precision, you can zoom in on image sections. Read SECTION 2.6.8 on this.

☞ If you want to import geometry data in point mode, you also have to perform a 2D and 3D alignment first. You will find detailed information on geometry import in SECTION 5.2.8.

PSV-3D

If you are using the PSV-3D, then you are making a measurement with three independent scanning heads. So you have to perform a 2D alignment for every individual scanning head first as described in the following.

After that, you have to perform a 3D alignment to position the three laser beams at one geometry point and have to transmit the vibration data into the coordinate system of the object under investigation. 3D alignment is described in SECTION 4.5.

☞ A 3D alignment without previous 2D alignment is possible. To make a measurement however, you will need both.

Start 2D alignment

To perform 2D alignment, proceed as follows:

1. Click [icon] or select Setup > 2D Alignment. The software maximizes the video window and displays the scanning head control.
2. If necessary, delete all existing alignment points first. To do so, click the video image with the right mouse button (not an alignment point) and select Delete All in the context menu.
3. Click the video image with the right mouse button and deactivate Auto Align in the context menu.

Position the laser beam

4. Move the laser beam with the icons Position in the scanning head control to an alignment point on the object, refer also to SECTION 4.1.1.

   With a bit of practice, you can position the laser beam more quickly for alignment by using the mouse to move it to approximately the right place first. If necessary, you can then use the scanning head control for fine-tuning as described above. Hold the middle mouse button (mouse wheel) pressed and drag across the video image with it. The laser beam follows the mouse cursor, although not very precisely yet, as 2D alignment has not yet been performed.

☞ If you have allocated a special function to the middle mouse button (e.g. double-click), then this method of alignment is not available.

To set the alignment points in detail on the object, you can use the optional PDA. To do so, start the PDA as described in SECTION 2.9. The user interface of the PDA software appears. The icon [icon] in the menu bar tells you that you are in 2D alignment.

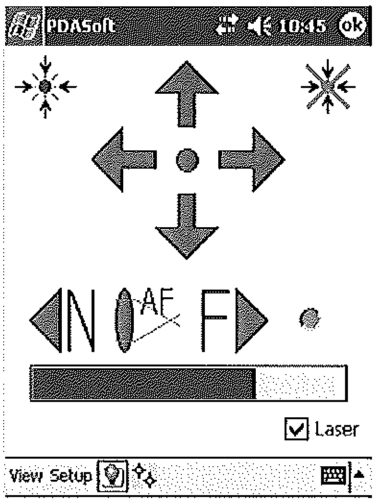


Figure 4.4: User interface of the PDA software

Center the laser beam by touching the icon ● with the stylus and position the laser beam by touching the corresponding icon for the direction ⇩, ⇧, ⇦ and ⇨. If you touch an arrow symbol for more than approx. one second, the PDA switches to fast forward. For fine adjustment you can always briefly touch the icon again.

☞ You can also use the 5-Way Navigation button on the PDA to position the laser beam. To do so, press the button for the corresponding direction.

Define alignment points

5. In the live video image, point the mouse precisely at the laser beam and click. You can now see a target there.

   If you are using the optional PDA, define an alignment point by touching the icon ⌖. You can also use the central Enter key on the PDA. The software searches for the laser beam in the video image and defines an alignment point at this position. If the software does not find the laser beam in the video image, defining the alignment point fails and a corresponding message appears on the PDA.

☞ Please make sure that you yourself are not caught by the video camera, as your movement can interfere with recognition of the laser beam.

6. If the laser beam is not precisely in the middle of the target, repeat step 5.
7. Repeat steps 4 to 6 for at least one other alignment point.
8. Once you have aligned all points, click ✧ again or select Setup > 2D Alignment.

Check alignment points

If you are using the optional PDA, you can check the defined alignment points with the laser beam by toggling the points on the object. To do so, select View > Toggle Points in the menu bar of the PDA.

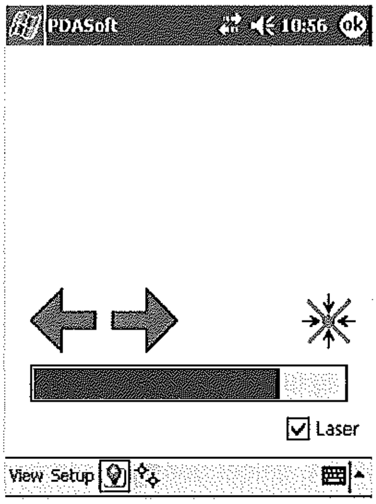


Figure 4.5: Toggle alignment points

Then touch the icon ⇦ or ⇨. The laser will toggle backwards or forwards towards the defined alignment points.

Delete alignment points

To delete an individual alignment point, click it with the right mouse button and select Delete in the context menu.

☞ If you are using the optional PDA, then you can delete an alignment point by positioning the laser beam on the alignment point and then touching the icon ✳. The software searches for the laser beam in the video image and deletes the alignment point at this position. If the software does not find the laser beam in the video image, deleting the alignment point fails and a corresponding message appears on the PDA. Please make sure that you yourself are not caught by the video camera, as your movement can interfere with recognition of the laser beam.

To delete all the alignment points for one scanning head, click the video image with the right mouse button and select Delete All in the context menu.

Special features for PSV-3D

If you are performing 2D alignment with the PSV-3D, please also pay attention to the following points:

☞ Before starting with the 2D alignment, you have to enter the correct angle of the scanning heads to the video camera in the dialog Setup > Preferences on the page Scanning Head (refer to SECTION 3.3 under Arrangement of scanning heads for the PSV-3D).

1. For the PSV-3D, define at least four alignment points for each scanning head. When doing so, the following applies:
   - In the case of simple level surfaces, it is often already enough to use four to six alignment points to get good results.
   - The larger the surface, the greater the deviations, particularly in the areas close to the edge.
   - If the results of the alignment are not satisfactory (see below in section Check alignment, step 3), then define at least ten alignment points per scanning head.

2. To select the individual scanning heads, use the list in the scanning head control or click the video image with the right mouse button and select one of the scanning heads (Top, Left or Right) in the context menu.

☞ When you select a new scanning head for alignment, the alignment points of the other scanning heads which have already been defined are saved.

If you are using the optional PDA, select one of the three scanning heads by touching the corresponding icon ◉ Top ○ Left ○ Right .

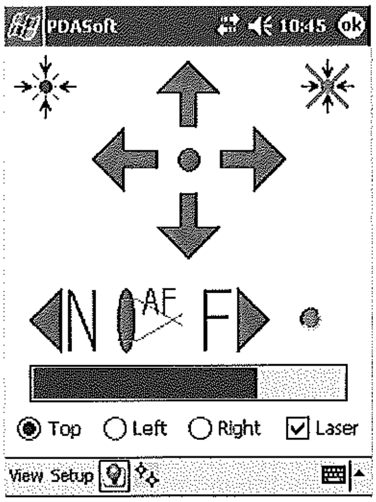


Figure 4.6: User interface of the PDA software for the PSV-3D

3. Once you have defined all alignment points for one scanning head, then select the other two scanning heads one after the other as described in step 2 and define the alignment points for these scanning heads in the same way.

☞ If you want to define scan points in the scan point definition, it is necessary for the laser beam and the point clicked on the screen to match as precisely as possible. If you import or teach-in the scan points as a Universal File, then an approximate match is good enough.

Align with Auto Align

You can perform an automatic 2D alignment. To do so, proceed as follows:

☞ Before starting with 2D alignment on the PSV-3D, you have to enter the correct angle of the scanning heads to the video camera in the dialog Setup > Preferences on the page Scanning Head (refer to SECTION 3.3 under Arrangement of scanning heads for the PSV-3D).

1. Click or select Setup > 2D Alignment. The software maximizes the video window and displays the scanning head control.
2. If necessary, delete all existing alignment points first. To do so, click the video image with the right mouse button (not an alignment point) and select Delete All in the context menu.
3. Click the video image with the right mouse button and select Auto Align in the context menu.
4. In the video image, click the point on the object at which you want to define the alignment point. The software will automatically position the laser beam there and define an alignment point.

☞ This function is not available for the MSA/MSV.

Abort alignment

You can abort the alignment at any time. To do so, click or select Setup > 2D Alignment. You will be given a message that the alignment was not finished correctly and you can now decide whether you want to repeat it or not.

Check alignment

Now test the 2D alignment as follows:

1. If the scan points are shown in the live video image, click to hide them.
2. Point at the live video image and click a point on the measurement plane. The laser beam moves to this point on the object.
3. Check if the position of the laser beam corresponds to that of the point clicked. If this is not the case, repeat the 2D alignment.

☞ The live video image shows a two-dimensional image of the three-dimensional object. For this reason, the laser beam does not precisely hit points which are not on the measurement plane.

4. Repeat steps 2 and 3 for a few more alignment points.

4.5 Performing 3D Alignment

3D alignment is always necessary if you want to use 3D geometries. 3D alignment determines the position and alignment of the scanning head (PSV/ MSA) or scanning heads (PSV-3D) in the coordinate system of the object.

☞ For the PSV-3D it is imperative that you perform 3D alignment. For the UHF, the 3D alignment is not necessary and not workable.

☞ With the micro scanning lenses PSV-A-CL80, PSV-A-CL150 and PSV-A-CL300 it is not possible to perform 3D alignment! The close-up unit without micro-scanning lenses does not affect 3D alignment.

For 3D alignment you need points on the measurement object for which the coordinate description is known in a cartesian coordinate system. You have to hit these points with the laser. The software will then calculate the 3D alignment.

In the following section you will find information on:

- Performing 3D Alignment for Different Systems, refer to SECTION 4.5.1
- Supporting 3D Alignment with the PSV-A-PDA, refer to SECTION 4.5.6
- Information for a Successful 3D Alignment, refer to SECTION 4.6

4.5.1 Performing 3D Alignment for Different Systems

PSV

For the PSV you have the following options for performing 3D alignment.

PSV	
Scanning head without geometry scan unit Go to SECTION 4.5.2.	Scanning head with geometry scan unit Go to SECTION 4.5.3.

PSV-3D

For the PSV-3D you have the following options for performing 3D alignment.

PSV-3D	
Without geometry scan unit Go to SECTION 4.5.4.	With geometry scan unit Go to SECTION 4.5.5.

MSA

For the MSA you have the following options for performing 3D alignment. For this purpose you will need either the option Data import: Geometry (ImpGeo) or the option MSAGeo.

MSA	
MSA-400/MSA-500 with option ImpGeo or MSA-500 with option MSAGeo	**MSA-500 with option MSAGeo**
3D alignment for the scanning head system Go to SECTION 4.5.7.	3D alignment for the object system Go to SECTION 4.5.8.

☞ Before carrying out a 3D alignment, make sure that you have set the correct zoom factor in the list Lens in the scanning head control. The software uses the zoom factor set to calculate the position of the laser on the object under investigation.

4.5.2 3D Alignment for the PSV without Geometry Scan Unit

If you are using a scanning head without geometry scan unit, proceed as follows for a 3D alignment:

2D alignment

1. If you have not performed 2D alignment yet, do it now as described in SECTION 4.4.

Open dialog

2. Click or select Setup > 3D Alignment. The video window is maximized and the dialog 3D Alignment appears. You can show or hide the dialog. To do so, click or select Setup > Dialog 3D Alignment.

   You can also click the video image with the right mouse button and select Dialog 3D Alignment in the context menu. The dialog 3D Alignment appears.

☞ If your PSV is equipped with a scanning head with geometry scan unit, then for this 3D alignment, deactivate the box Auto next to Assign Coordinates to Point. If you want to use the geometry scan unit, read SECTION 4.5.3.

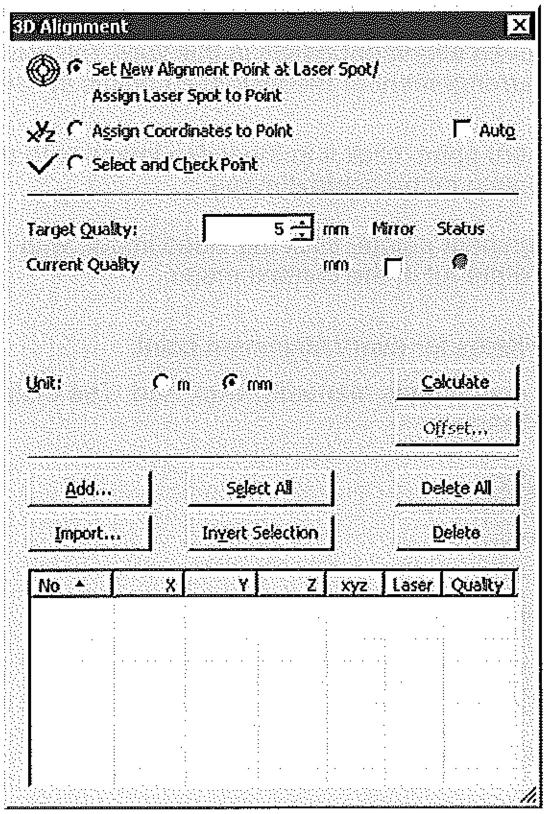


Figure 4.7: Dialog 3D Alignment for the PSV without geometry scan unit

Select the unit

3. Select the unit for the coordinates (m or mm).

Position the laser beam

4. Now you can move the laser beam using the icons Position in the scanning head control.

   Alternatively you can also use the mouse directly. Using the middle mouse button (mouse wheel), click in the video image. This will make the laser beam jump to your mouse cursor. To position the beam, hold the middle mouse button pressed and drag with the mouse until the laser beam is positioned on the required point on the object.

   ☞ If you have assigned a special function to the middle mouse button (e.g. double-click), position the laser beam using the icons Position in scanning head control.

   To increase the accuracy when hitting the required point, zoom the video image. See SECTION 2.6.8 on this.

Define alignment points

5. Once you have found the precise position of the required point on the object, in the dialog 3D Alignment select Set New Alignment Point at Laser Spot/Assign Laser Spot to Point. Now in the video image, click the point which the laser beam is currently at. An alignment point will now be defined there. The alignment point is marked using a black circle.

6. Define four to seven alignment points in this way. You will find information on appropriate arrangement of the alignment points in SECTION 4.6.

Delete alignment points

To delete an alignment point, click it in the video image with the right mouse button and select Delete in the context menu.

To delete all the alignment points, click the video image with the right mouse button and select Delete All in the context menu.

Set the coordinates

7. Enter the coordinates for every alignment point.

   If you enter the coordinates manually, click Add. The dialog Add Coordinates appears.

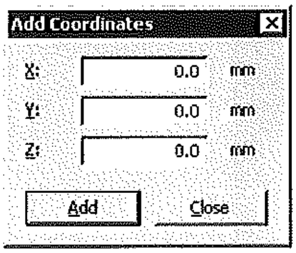


Figure 4.8: Dialog Add Coordinates

   Enter the values in the fields X, Y and Z and click Add. Once you have entered coordinates for all the alignment points, click Close or press the Escape key to leave the dialog.
   If you want to import the coordinates e.g. from an external program, then click Import. Then enter the file which you want to import the values from.

   ☞ When you import, all coordinate lines that already exist in the dialog 3D Alignment will be deleted!

☞ If you are importing geometry from a file in ASCII format or a file in Universal File format which does not contain data set 164 with the units of the coordinates, you have to enter a scaling factor in the dialog 3D Alignment (refer to FIGURE 4.9). Factor 1 stands for the unit 1 m, factor 0.01 for the unit 1 cm etc.

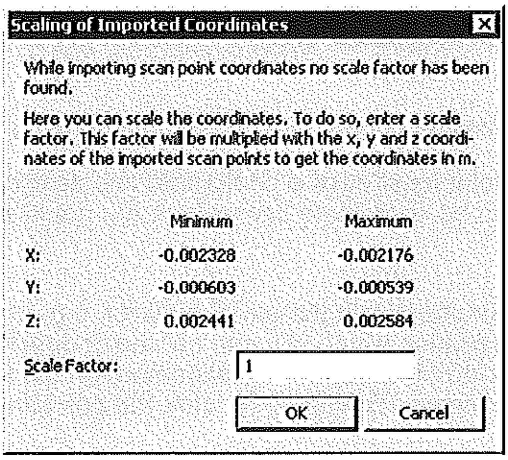


Figure 4.9: Dialog Scaling of Imported Coordinates

Delete coordinate lines

If the table contains too many coordinate lines, you can delete individual lines. To do so, mark one or more lines and click Delete. Or mark the coordinate lines you want to keep, click Invert Selection and then Delete. This way you will delete all the undesired lines at once.

If you want to delete all coordinate lines at once, click Delete All.

☞ If alignment points on the video image are already linked with the coordinates in the table, then the coordinates assigned to the points are deleted, the alignment points themselves however remain.

Assign coordinates

8. Then in the dialog 3D Alignment, select Assign Coordinates to Point.
9. In the dialog 3D Alignment, mark the first coordinate line in the table and click the associated alignment point in the video image. A tick will appear in each of the columns xyz and Laser. These show that the coordinates of this line are now assigned to an alignment point. The circle in the video image is now shown in bold and the marker in the table moves on one line.
10. Now, in the table, assign coordinates to each alignment point.

☞ Every alignment point must have a coordinate line assigned to it here. However, there can be coordinate lines which are not assigned to an alignment point.

Use mirror

If you make the measurement with the aid of a mirror, e.g. to scan a side of the object under investigation which you can not reach directly with the laser beam, you have to perform the 2D and 3D alignment on the mirror image. Apart from that, in the dialog 3D Alignment mark the box Mirror.

☞ Please note that for a scan, the scanning head can only be aligned either to the mirror image or directly on the object. However, you can carry out two scans with and without the mirror and then combine them (refer to SECTION 8.5). To do so, you will need an individual 3D alignment for each scan.

Specify quality

11. In the field Target Quality enter the maximum value by which the alignment points may deviate from the given coordinates (e.g. 1 mm).

Calculate the alignment

Once you have defined the alignment points and have assigned coordinates to them, you can calculate the alignment.

12. Click Calculate. The software will now calculate the alignment. The current quality of this alignment is shown in the dialog. If the 3D alignment is successful, then the LED Status will turn green. If the LED lights up red, then the alignment is not valid.

☞ If the value for the current quality exceeds the value for the target quality, then a message will appear. The LED Status will turn yellow. Despite this, you can use the 3D alignment.

You can check the quality for the individual alignment points. The alignment points for which the quality value for the respective scanning head is lower than the value in the field Target Quality will have a tick in the column Quality.

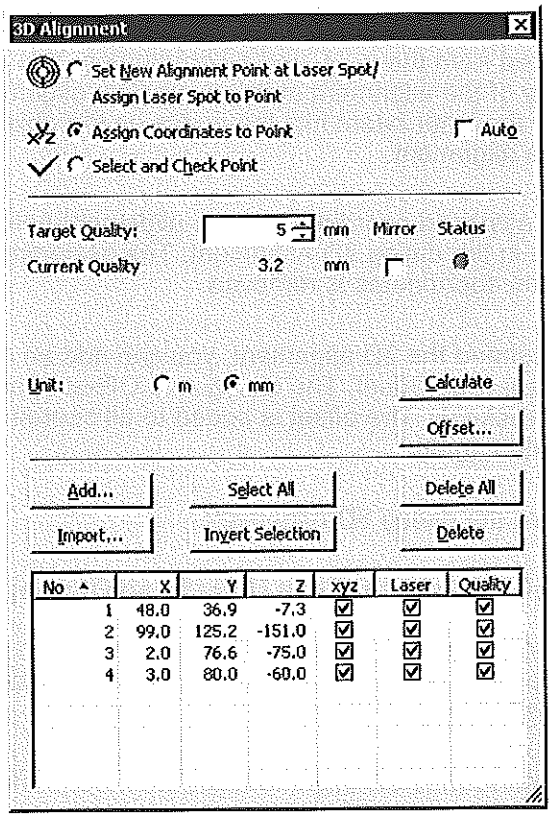


Figure 4.10: Successful 3D alignment for the PSV without geometry scan unit

☞ You can sort the entries in the table in ascending or descending order in every column. To do so, click the head of the respective column.

Reassign the laser position

You can also reassign new laser positions to existing alignment points to increase the quality of the measurement results. To do so, in the dialog 3D Alignment select Set New Alignment Point at Laser Spot/Assign Laser Spot to Point. Then move the relevant laser beam to the point on the object and click the alignment point in the video image with the left mouse button. The new laser position is used to calculate the alignment again.

Abort alignment

You can abort the alignment at any time. To do so, click or select Setup > 3D Alignment. You will be given a message that the alignment was not finished correctly and you can now decide whether you want to repeat it or not.

Check alignment points

You can also retrospectively check the assignment of the alignment points on the video image with the coordinates in the table of the dialog 3D Alignment.

13. To do so, in the dialog 3D Alignment, select Select and Check Point.

14. Then click an alignment point in the video image. The corresponding line in the table is marked.

    Or click a line in the table. The corresponding alignment point is displayed blue in the video image.

☞ If a valid 3D alignment is available, then the laser beam is moved to the position calculated from the x-, y- and z-coordinates. You can visually check the quality of the alignment at the respective alignment point. The more accurately the laser beam hits the points on the object, the higher the quality of the alignment.

Clear assignment

If you have already assigned coordinates to an alignment point, delete the respective table line in the dialog 3D Alignment. The assignment of the alignment point to the coordinates is removed.

Add offset

Once you have calculated the 3D alignment, you can add an offset to the coordinates. To do so, click Offset. The dialog Add Offset appears. Enter the required offset and click OK. The offset is added to all coordinates and the alignment is calculated again.

End alignment

15. Click to leave the dialog 3D Alignment.

4.5.3 3D Alignment for the PSV with Geometry Scan Unit (as an Option)

The optional geometry scan unit will make it easier for you to perform 3D alignment. If you are using a scanning head with geometry scan unit, proceed as follows for a 3D alignment:

2D alignment

1. If you have not performed 2D alignment yet, do it now as described in SECTION 4.4.

Open dialog

2. Click or select Setup > 3D Alignment. The video window is maximized and the dialog 3D Alignment appears. You can show or hide the dialog. To do so, click or select Setup > Dialog 3D Alignment.

You can also click the video image with the right mouse button and select Dialog 3D Alignment in the context menu. The dialog 3D Alignment appears.

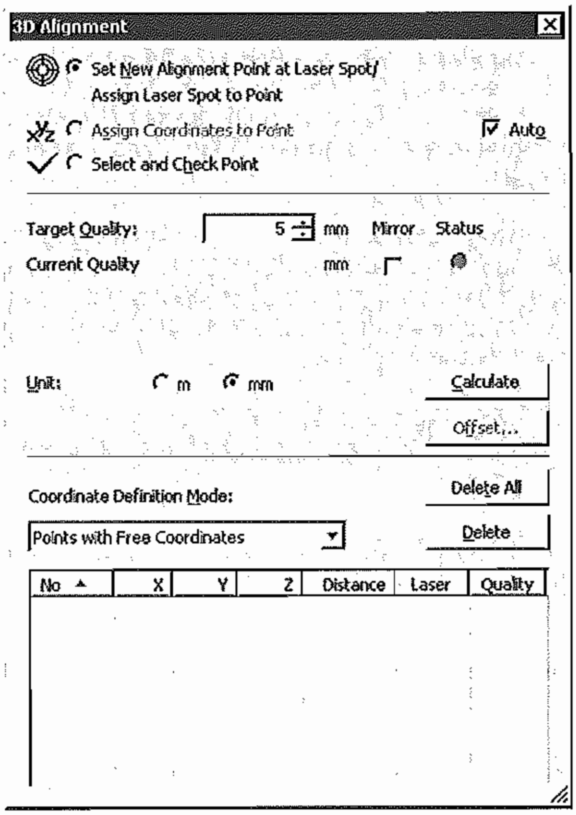


Figure 4.11: Dialog 3D Alignment for the PSV with geometry scan unit

Activate geometry scan unit

3. Mark the box Auto next to Assign Coordinates to Point to use the geometry scan unit for 3D alignment.

Select the unit

4. Select the unit for the coordinates (m or mm).

Position the laser beam

5. Now you can move the laser beam using the icons Position in the scanning head control.

   Alternatively you can also use the mouse directly. Using the middle mouse button (mouse wheel), click in the video image. This will make the laser beam jump to your mouse cursor. To position the beam, hold the middle mouse button pressed and drag with the mouse until the laser beam is positioned at the required point on the object.

☞ If you have assigned a special function to the middle mouse button (e.g. double-click), position the laser beam using the icons Position in the scanning head control.

To increase the accuracy when hitting the required point, zoom the video image. See SECTION 2.6.8 on this.

Define alignment points

6. Once you have found the precise position of the required point on the object, in the dialog 3D Alignment select Set New Alignment Point at Laser Spot/Assign Laser Spot to Point. Now in the video image, click the point which the laser beam is currently at. An alignment point will now be defined there. The alignment point is marked with a black circle and a line is added to the dialog 3D Alignment which is automatically assigned to the alignment point. In the column Distance the distance measured to this alignment point is entered. In the column Laser it shows that the point has been defined.

☞ When defining every alignment point, the software automatically switches over to the geometry laser and carries out a distance measurement to the alignment point. When defining the alignment points, you can save time by activating the geometry laser first to avoid having to switch over. To do so, select Scan > Geometry Laser.

7. Define three to twenty alignment points in this way. You will find information on appropriate arrangement of the alignment points in SECTION 4.6.

Delete alignment points

To delete an alignment point, click it in the video image with the right mouse button and select Delete in the context menu. You can also mark the corresponding line of the table in the dialog 3D Alignment and click Delete.

To delete all the alignment points, click the video image with the right mouse button and select Delete All in the context menu.

Define and assign coordinates

You have the following options to define the object coordinate system (object system):

- Points with Free Coordinates: You mark at least three points and enter all the coordinates of these points.
- Origin, Axis, Plane: You mark the origin, any point of your choice along the positive x-, y- or z-axis and any point in the positive half plane limited by the selected axis (e.g. 0, +x, x/+y).
- Three Points on Axes: You each mark any point on the positive x-, y- and z-axis.

In the following the option Points with Free Coordinates is described in detail. Both the other options will be explained to you briefly at the end of this section.

8. Select Points with Free Coordinates from the list Coordinate Definition Mode.

9. Click the alignment point with the right mouse button and select Point with Free Coordinates in the context menu. The dialog Assign Coordinates appears.

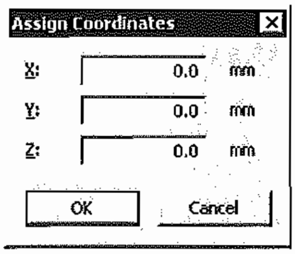


Figure 4.12: Dialog Assign Coordinates

10. Here you enter the coordinates of the alignment point and click OK. XYZ will appear next to the point.

11. Repeat steps 9 and 10 until you have assigned coordinates to at least three alignment points.

☞ If you have defined more than three alignment points, then you do not have to assign coordinates to all the alignment points. However, only alignment points which have had coordinates assigned to them will be used to calculate the 3D alignment. For further information please read SECTION 4.6.

Use mirror

If you make the measurement with the aid of a mirror, e.g. to scan a side of the object under investigation which you can not reach directly with the laser beam, you have to perform the 2D and 3D alignment on the mirror image. Apart from that, in the dialog 3D Alignment mark the box Mirror.

☞ Please note that for a scan, the scanning head can only be aligned either to the mirror image or directly on the object. However, you can carry out two scans with and without the mirror and then combine them (refer to SECTION 8.5). To do so, you will need an individual 3D alignment for each scan.

Specify quality

12. In the field Target Quality enter the maximum value by which the alignment points may deviate from the given coordinates (e.g. 1 mm).

Calculate the alignment

Once you have defined the alignment points and have assigned coordinates to them, you can calculate the alignment.

13. Click Calculate. The software will now calculate the alignment. The current quality of this alignment is shown in the dialog. If the 3D alignment is successful, then the LED Status will turn green. If the LED lights up red, then the alignment is not valid.

☞ If the value for the current quality exceeds the value for the target quality, then a message will appear. The LED Status will turn yellow. Despite this, you can use the 3D alignment.

You can check the quality for the individual alignment points. The alignment points for which the quality value for the respective scanning head is lower than the value in the field Target Quality will have a tick in the column Quality.

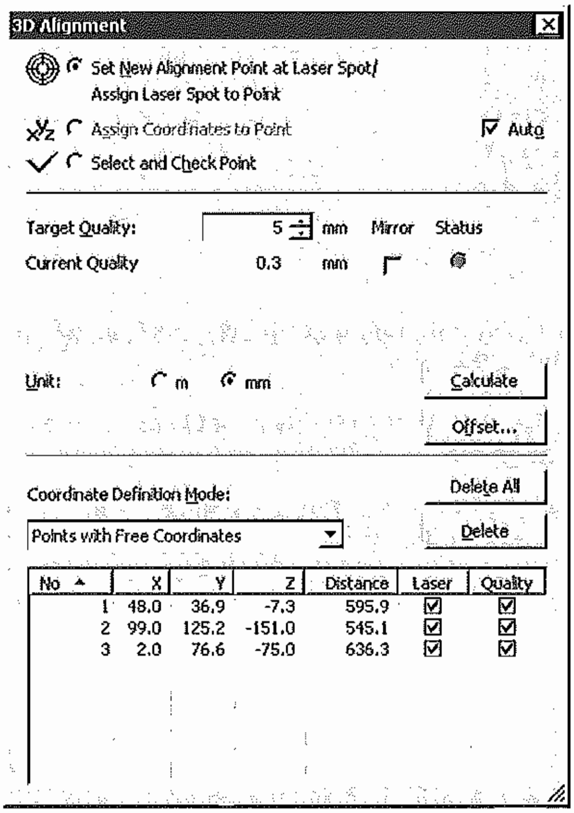


Figure 4.13: Successful 3D alignment for the PSV with geometry scan unit

☞ You can sort the entries in the table in ascending or descending order in every column. To do so, click the head of the respective column.

Reassign the laser position You can also reassign new laser positions to existing alignment points to increase the quality of the measurement results. To do so, in the dialog 3D Alignment select Set New Alignment Point at Laser Spot/Assign Laser Spot to Point. Then move the relevant laser beam to the point on the object and click the alignment point in the video image with the left mouse button. The software will carry out a new distance measurement to the alignment point. The new laser position and distance are used to recalculate the alignment.

Abort alignment You can abort the alignment at any time. To do so, click or select Setup > 3D Alignment. You will be given a message that the alignment was not finished correctly and you can now decide whether you want to repeat it or not.

Check alignment points You can also retrospectively check the assignment of the alignment points on the video image with the coordinates in the table of the dialog 3D Alignment.

14. To do so, in the dialog 3D Alignment, select Select and Check Point.

15. Then click an alignment point in the video image. The corresponding line in the table is marked.

    Or click a line in the table. The corresponding alignment point is displayed blue in the video image.

☞ If a valid 3D alignment is available, then the laser beam is moved to the position calculated from the x-, y- and z-coordinates. You can visually check the quality of the alignment at the respective alignment point. The more accurately the laser beam hits the points on the object, the higher the quality of the alignment.

Add offset

Once you have calculated the 3D alignment, you can add an offset to the coordinates. To do so, click Offset. The dialog Add Offset appears. Enter the required offset and click OK. The offset is added to all coordinates and the alignment is calculated again.

☞ If you have selected a different coordinate definition mode than Points with Free Coordinates, then when an offset is added, the software will automatically switch into the mode Points with Free Coordinates.

End alignment

16. Click to leave the dialog 3D Alignment.

Alternative coordinate definition

Origin, Axis, Plane

To define the object coordinate system this way, replace steps 8 to 11 in section Define and assign coordinates with the following:

1. Select Origin, Axis, Plane from the list Coordinate Definition Mode.

2. With the right mouse button, click the alignment point which you want to define as origin and select Origin in the context menu. Next to the alignment point a 0 appears. The origin coordinates (0/0/0) are displayed in the dialog 3D alignment.

3. With the right mouse button, click the alignment point which you want to define on the x-axis for example and select Point on +x-axis in the context menu. An +x will appear next to the point; an arrow will be drawn through the point. The distance and the coordinates (+x/0/0) of the point are shown in the dialog 3D Alignment.

4. With the right mouse button, click the alignment point which you want to define in a half-plane and select for example Point on x/+y plane in the context menu. An x/+y will appear next to the point. The distance and the coordinates (x/+y/0) of the point are shown in the dialog 3D Alignment.

5. Now continue with the 3D alignment as described from step 12 onwards further up.

☞ The target quality also has to be entered in this coordinate definition mode. The current quality ascertained is always 0. If you have defined more than three alignment points, the excess alignment points are not taken into consideration when calculating the 3D alignment.

Three Points on Axes

To define the object coordinate system this way, replace steps 8 to 11 in section Define and assign coordinates with the following:

1. Select Three Points on Axes from the list Coordinate Definition Mode.
2. Use the right mouse button to click the alignment point which the x-axis of the coordinate system is to run through and select Point on +x-axis in the context menu. An +x will appear next to the point; an arrow will be drawn through the point.
3. Repeat step 2 for one more alignment point each on the y- and z-axis.
4. Now continue with the 3D alignment as described from step 12 onwards further up.

☞ The target quality also has to be entered in this coordinate definition mode. The current quality ascertained is always 0. If you have defined more than three alignment points, the excess alignment points are not taken into consideration when calculating the 3D alignment.

4.5.4 3D Alignment for the PSV-3D without an Activated Geometry Scan Unit

☞ If you are using the PSV-3D in 1D mode, you only have to perform the 3D alignment for the scanning heads which are not marked as reference.

If you are using your PSV-3D without an activated geometry scan unit, proceed as follows for a 3D alignment:

2D alignment

1. If you have not performed 2D alignment yet, do it now as described in SECTION 4.4.

Open dialog

2. Click or select Setup > 3D Alignment. The video window is maximized and the dialog 3D Alignment appears. You can show or hide the dialog. To do so, click or select Setup > Dialog 3D Alignment.

   You can also click the video image with the right mouse button and select Dialog 3D Alignment in the context menu. The dialog 3D Alignment appears.

☞ Deactivate the box Auto next to Assign Coordinates to Point. If you want to use the geometry scan unit, read SECTION 4.5.5.

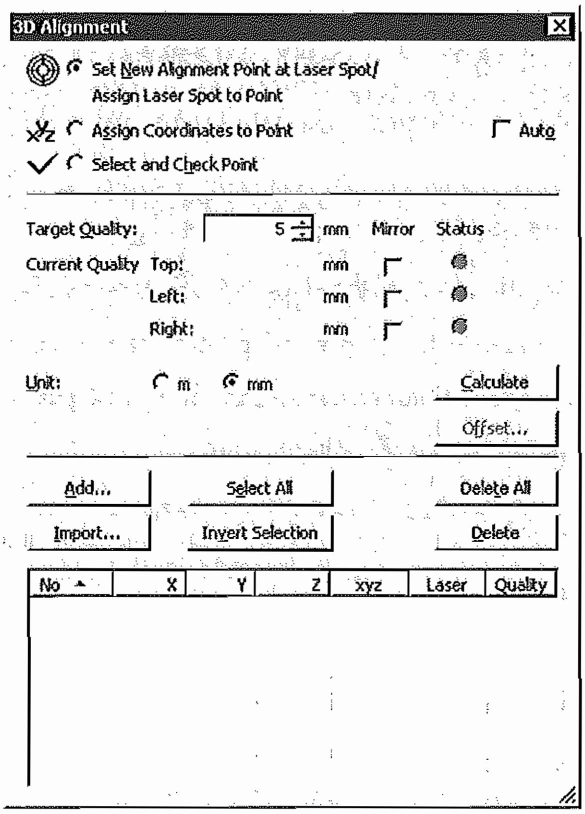


Figure 4.14: Dialog 3D Alignment for the PSV-3D without an activated geometry scan unit

Select the unit

3. Select the unit for the coordinates (m or mm).

Select scanning head

4. In the scanning head control, select a scanning head, or with the right mouse button, click the video image and select one of the scanning heads (Top, Left or Right) in the context menu.

Position the laser beam

5. Now you can move the laser beam using the icons Position in the scanning head control.

   Alternatively you can also use the mouse directly. Using the middle mouse button (mouse wheel), click in the video image. This will make the laser beam jump to your mouse cursor. To position the beam, hold the middle mouse button pressed and drag with the mouse until the laser beam is positioned on the required point on the object.

☞ If you have assigned a special function to the middle mouse button (e.g. double-click), position the laser beam using the icons Position in the scanning head control.

To increase the accuracy when hitting the required point, zoom the video image. See SECTION 2.6.8 on this.

Define alignment points

6. Once you have found the precise position of the required point on the object, in the dialog 3D Alignment select Set New Alignment Point at Laser Spot/Assign Laser Spot to Point. Now in the video image, click the point which the laser beam is currently at. An alignment point will now be defined there.

   The alignment point is marked using a black circle. This icon shows you which scanning head you are currently aligning:

   designates the left, the right and the top scanning head.

☞ If for example, you click on the same place in the video image for the top and the left scanning head one after the other, you will be shown . For all three scanning heads will appear.

7. In this way you define four to seven alignment points for all three scanning heads. These alignment points can be the same for all three scanning heads, but this is not necessary. You will find information on appropriate arrangement of the alignment points in SECTION 4.6.

Delete alignment points

To delete an alignment point, click it in the video image with the right mouse button and select Delete in the context menu.

To delete all the alignment points, click the video image with the right mouse button and select Delete All in the context menu.

Set the coordinates

8. Enter the coordinates for every alignment point.

   If you enter the coordinates manually, click Add. The dialog Add Coordinates appears.

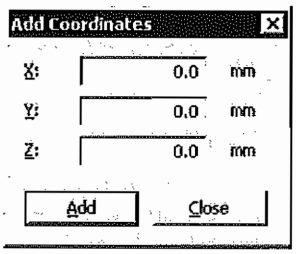


Figure 4.15: Dialog Add Coordinates

Enter the values in the fields X, Y and Z and click Add. Once you have entered coordinates for all the alignment points, click Close or press the Escape key to leave the dialog.
If you want to import the coordinates e.g. from an external program, then click Import. Then enter the file which you want to import the values from.

☞ When you import, all coordinate lines that already exist in the dialog 3D Alignment will be deleted!

☞ If you are importing geometry from a file in ASCII format or a file in Universal File format which does not contain data set 164 with the units of the coordinates, you have to enter a scaling factor in the dialog 3D Alignment (refer to FIGURE 4.16). Factor 1 stands for the unit 1 m, factor 0.01 for the unit 1 cm etc.

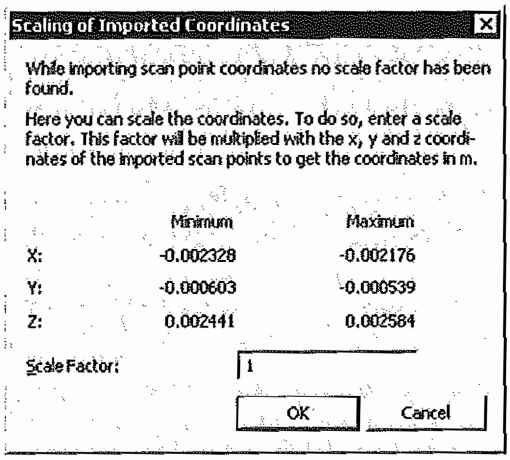


Figure 4.16: Dialog Scaling of Imported Coordinates

Delete coordinate lines

If the table contains too many coordinate lines, you can delete individual lines. To do so, mark one or more lines and click Delete. Or mark the coordinate lines you want to keep, click Invert Selection and then Delete. This way you will delete all the undesired lines at once.

If you want to delete all coordinate lines, click Delete All.

☞ If alignment points on the video image are already linked with the coordinates in the table, then the coordinates assigned to the points are deleted, the alignment points themselves however remain.

Assign coordinates

9. Then in the dialog 3D Alignment, select Assign Coordinates to Point.

10. In the dialog 3D Alignment, mark the first coordinate line in the table and click the associated alignment point in the video image. In the column xyz a tick will appear which shows that the coordinates in this line are now assigned to an alignment point. The circle in the video image is now shown in bold and the marker in the table moves on one line.

☞ If you have assigned coordinates to an alignment point, then in the dialog 3D Alignment in the table Laser you will see for which scanning head you have already defined the respective alignment point. The three dots in the icon stand for the three laser beams Top, Left and Right.

11. Now, in the table, assign coordinates to each alignment point.

☞ Every alignment point must have a coordinate line assigned to it here. However, there can be coordinate lines which are not assigned to an alignment point.

Use mirror

If you make the measurement with the aid of a mirror or several mirrors, e.g. to scan a side of the object which you can not reach directly with the laser beam, you have to perform 2D and the 3D alignment for the respective scanning head on the reflection of the object. Apart from that, in the dialog 3D Alignment, tick the corresponding box in the column Mirror.

☞ Please note that for a scan, each scanning head can only be aligned either to the mirror image or directly on the object. However, you can carry out two scans with and without the mirror and then combine them (refer to SECTION 8.5). To do so, you will need an individual 3D alignment for each scan.

Specify quality

12. In the field Target Quality enter the maximum value by which the alignment points may deviate from the given coordinates (e.g. 1 mm).

Calculate the alignment

Once you have defined the alignment points for all three scanning heads and have assigned coordinates to them, you can calculate the alignment.

13. Click Calculate. The software will now calculate the alignment for each scanning head. The current quality of this alignment is displayed in the dialog for every scanning head. If 3D alignment for a scanning head is successful, then the respective LED Status will be green. If the LED lights up red, then the alignment is not valid.

☞ If the value for the current quality exceeds the value for the target quality for one or more scanning heads, then a message will appear. The respective LED Status will turn yellow. Despite this, you can use the 3D alignment.

You can check the quality for the individual alignment points. In the column Quality up to three green markers will be displayed for one alignment point if the quality value for the respective scanning head falls below the value in the field Target Quality.

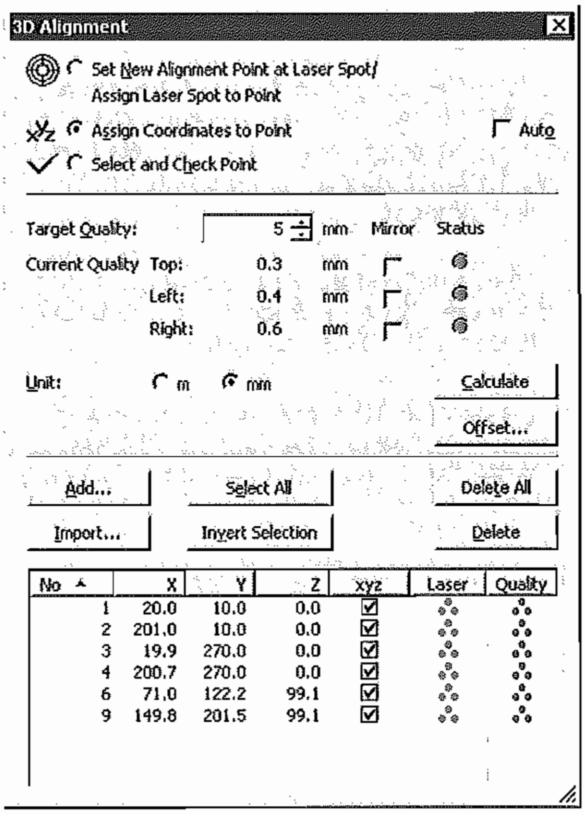


Figure 4.17: Successful 3D alignment for the PSV-3D without activated geometry scan unit

☞ You can sort the entries in the table in ascending or descending order in every column. To do so, click the head of the respective column.

Reassign the laser position

You can also reassign new laser positions to existing alignment points to increase the quality of the measurement results. To do so, in the dialog 3D Alignment select Set New Alignment Point at Laser Spot/Assign Laser Spot to Point. Then move the respective laser beam to the point on the object and click the alignment point in the video image with the left mouse button. The new laser position is used to calculate the alignment again.

Abort alignment

You can abort the alignment at any time. To do so, click or select Setup > 3D Alignment. You will be given a message that the alignment was not finished correctly and you can now decide whether you want to repeat it or not.

Check alignment points

You can also retrospectively check the assignment of the alignment points on the video image with the coordinates in the table of the dialog 3D Alignment.

14. To do so, in the dialog 3D Alignment, select Select and Check Point.

15. Then click an alignment point in the video image. The corresponding line in the table is marked.

Or click a line in the table. The corresponding alignment point is displayed blue in the video image.

☞ If there is valid 3D alignment, then the laser beams are moved to the positions calculated for the x-, y- and z-coordinates. You can visually check the quality of the alignment at the respective alignment point. The more accurately the laser beams hit the points on the object, the higher the quality of the alignment.

Clear assignment If you have already assigned coordinates to an alignment point, delete the respective table line in the dialog 3D Alignment. The assignment of the alignment point to the coordinates is removed.

Add offset Once you have calculated the 3D alignment, you can add an offset to the coordinates. To do so, click Offset. The dialog Add Offset appears. Enter the required offset and click OK. The offset is added to all coordinates and the alignment is calculated again.

End alignment 16. Click to leave the dialog 3D Alignment.

4.5.5 3D Alignment for the PSV-3D with Geometry Scan Unit

☞ If you are using the PSV-3D in 1D mode, you only have to perform the 3D alignment for the scanning heads which are not marked as reference.

The geometry scan unit will make it easier for you to perform 3D alignment. If you are using a PSV-3D with a geometry scan unit, proceed as follows for a 3D alignment:

2D alignment

1. If you have not performed 2D alignment yet, do it now as described in SECTION 4.4.

Open dialog

2. Click or select Setup > 3D Alignment. The video window is maximized and the dialog 3D Alignment appears. You can show or hide the dialog. To do so, click or select Setup > Dialog 3D Alignment.

   You can also click the video image with the right mouse button and select Dialog 3D Alignment in the context menu. The dialog 3D Alignment appears.

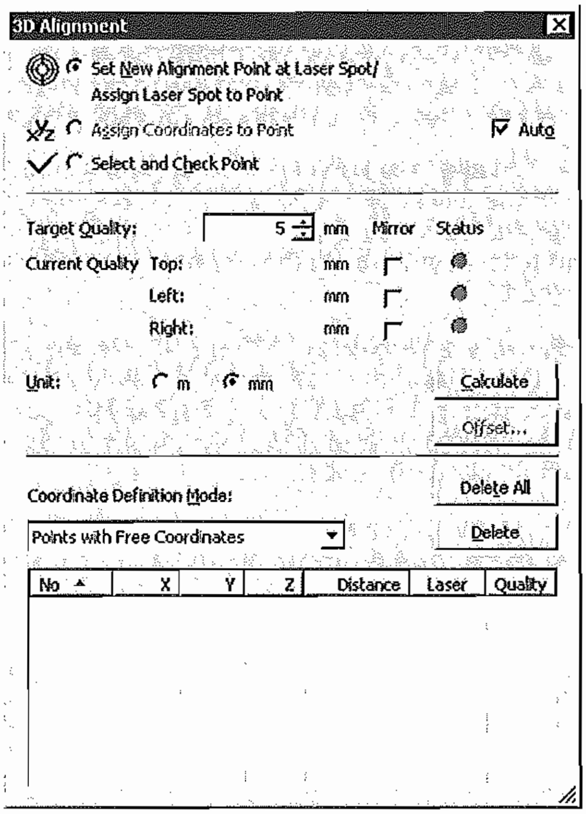


Figure 4.18: Dialog 3D Alignment for the PSV-3D with geometry scan unit

Activate geometry scan unit

3. Mark the box Auto next to Assign Coordinates to Point to use the geometry scan unit for 3D alignment.

Select the unit

4. Select the unit for the coordinates (m or mm).

Select scanning head Top

5. In the scanning head control, select the scanning head Top or click the video image with the right mouse button and select Scanning Head Top in the context menu.

Position the laser beam

6. Now you can move the laser beam using the icons Position in the scanning head control.

   Alternatively you can also use the mouse directly. Using the middle mouse button (mouse wheel), click in the video image. This will make the laser beam jump to your mouse cursor. To position the beam, hold the middle mouse button pressed and drag with the mouse until the laser beam is positioned on the required point on the object.

☞ If you have assigned a special function to the middle mouse button (e.g. double-click), position the laser beam using the icons Position in the scanning head control.

To increase the accuracy when hitting the required point, zoom the video image. See SECTION 2.6.8 on this.

Define alignment points

7. Once you have found the precise position of the required point on the object, in the dialog 3D Alignment select Set New Alignment Point at Laser Spot/Assign Laser Spot to Point. Now in the video image, click the point which the laser beam is currently at. An alignment point will now be defined there. The alignment point is marked with a black circle and a line is added to the dialog 3D Alignment which is automatically assigned to the alignment point. In the column Distance the distance measured to this alignment point is entered. In the column Laser it shows that the point has been defined.

☞ When defining every alignment point, the software automatically switches over to the geometry laser and carries out a distance measurement to the alignment point. When defining the alignment points, you can save time by activating the geometry laser first to avoid having to switch over. To do so, select Scan > Geometry Laser.

8. Define three to twenty alignment points in this way. You will find information on appropriate arrangement of the alignment points in SECTION 4.6.

Delete alignment points

To delete an alignment point, click it in the video image with the right mouse button and select Delete in the context menu. You can also mark the corresponding line of the table in the dialog 3D Alignment and click Delete.

To delete all the alignment points, click the video image with the right mouse button and select Delete All in the context menu.

Define and assign coordinates

You have the following options to define the object coordinate system (object system):

- Points with Free Coordinates: You mark at least three points and enter all the coordinates of these points.
- Origin, Axis, Plane: You mark the origin, any point of your choice along the positive x-, y- or z-axis and any point in the positive half plane limited by the selected axis (e.g. 0, +x, x/+y).
- Three Points on Axes: You each mark any point on the positive x-, y- and z-axis.

In the following the option Points with Free Coordinates is described in detail. Both the other options will be explained to you briefly at the end of this section.

9. Select Points with Free Coordinates from the list Coordinate Definition Mode.

10. Click the alignment point with the right mouse button and select Point with Free Coordinates in the context menu. The dialog Assign Coordinates appears.

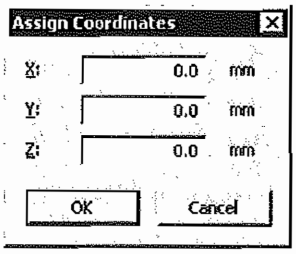


Figure 4.19: Dialog Assign Coordinates

11. Here you enter the coordinates of the alignment point and click OK. XYZ will appear next to the point.

12. Repeat steps 10 and 11 until you have assigned coordinates to at least three alignment points.

☞ If you have defined more than three alignment points, then you do not have to assign coordinates to all the alignment points. However, only alignment points which have had coordinates assigned to them will be used to calculate the 3D alignment for the scanning head Top. For further information please read SECTION 4.6.

Use mirror

If you make the measurement with the aid of a mirror or several mirrors, e.g. to scan a side of the object under investigation which you can not reach directly with the laser beam, you have to perform the 2D and 3D alignment on the mirror image. Apart from that, in the dialog 3D Alignment, tick the corresponding box in the column Mirror.

☞ Please note that for a scan, each scanning head can only be aligned either to the mirror image or directly on the object. However, you can carry out two scans with and without the mirror and then combine them (refer to SECTION 8.5). To do so, you will need an individual 3D alignment for each scan.

Specify quality

13. In the field Target Quality enter the maximum value by which the alignment points may deviate from the given coordinates (e.g. 1 mm).

Calculate the alignment

Once you have defined the alignment points for the scanning head Top and have assigned coordinates to them, you can calculate the alignment for the scanning head Top.

14. Click Calculate. The software will now calculate the alignment only for the scanning head Top. The current quality of this alignment is shown in the dialog. If 3D alignment for a scanning head Top is successful, then the corresponding LED Status will be green. If the LED lights up red, then the alignment is not valid.

☞ As you have not yet defined any alignment points for the scanning heads Left and Right you will definitely get a message. However, if the value for the current quality for the scanning head Top exceeds the value for the target quality, then this will also be listed in the message. The LED Status will turn yellow. Despite this, you can use the 3D alignment.

You can check the quality for the individual alignment points. In the column Quality one green marker will be displayed for one alignment point if the quality value for the scanning head Top falls below the value in the field Target Quality.

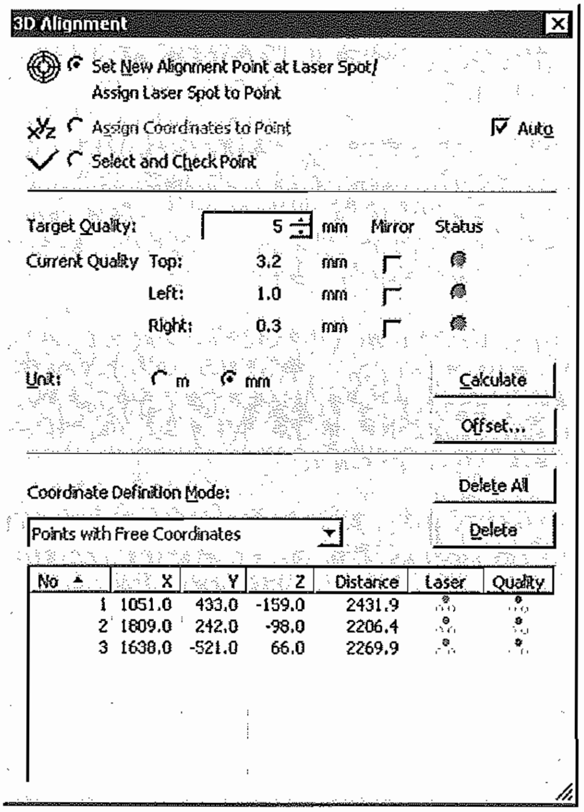


Figure 4.20: Successful 3D alignment for the scanning head Top with geometry scan unit

☞ You can sort the entries in the table in ascending or descending order in every column. To do so, click the head of the respective column.

Reassign the laser position

You can also reassign new laser positions to existing alignment points to increase the quality of the measurement results. To do so, in the dialog 3D Alignment select Set New Alignment Point at Laser Spot/Assign Laser Spot to Point. Then move the relevant laser beam to the point on the object and click the alignment point in the video image with the left mouse button. The software will carry out a new distance measurement to the alignment point. The new laser position and distance are used to recalculate the alignment.

Complete alignment

Now perform 3D alignment for the scanning heads Left and Right. You define the coordinates of the alignment points for these scanning heads with the aid of the scanning head Top. To do so, continue as follows:

15. Move the laser beam of the scanning head Top to the required position.

☞ While doing so, it is not absolutely necessary for the point to be on the object or respectively in the video image. Read SECTION 4.6 on this.

16. Once you have found the precise position of the required point, in the dialog 3D Alignment select Set New Alignment Point at Laser Spot/ Assign Laser Spot to Point.

17. Now in the video image, click the point which the laser beam is currently at. An alignment point will now be defined there. The alignment point is marked with a circle and a line is added to the dialog 3D Alignment which is automatically assigned to the alignment point.

18. Select the scanning head Left and move the laser beam to the same point at which you positioned the laser of the scanning head Top.

19. In the video image, click the point which the laser beam is currently at. An alignment point is now defined there for the scanning head Left. The alignment point is now marked with the circle .

20. Select the scanning head Right and move the laser beam to the same point at which you positioned the lasers of the scanning heads Top and Left.

21. In the video image, click the point which the laser beams are currently at. An alignment point is now defined there for the scanning head Right. The alignment point is now marked with the circle .

22. Now define four to seven alignment points this way for the scanning heads Left and Right which also each have to be defined with the scanning head Top. You will find information on appropriate arrangement of the alignment points in SECTION 4.6.

☞ Please note that the alignment points defined in this way are not used for calculating the 3D alignment for the scanning head Top. You have to define these alignment points with the scanning head Top so that the coordinates for the alignment points for scanning heads Left and Right can be calculated.

Once you have defined the alignment points for all three scanning heads, you can calculate the alignment for all three scanning heads.

23. Click Calculate. The software will now calculate the alignment for each scanning head. The current quality of this alignment is displayed in the dialog for every scanning head. If 3D alignment for a scanning head is successful, then the respective LED Status will be green. If the LED lights up red, then the alignment is not valid.

☞ If the value for the current quality exceeds the value for the target quality for one or more scanning heads, then a message will appear. The respective LED Status will turn yellow. Despite this, you can use the 3D alignment.

You can check the quality for the individual alignment points. In the column Quality up to three green markers will be displayed for one alignment point if the quality value for the respective scanning head falls below the value in the field Target Quality.

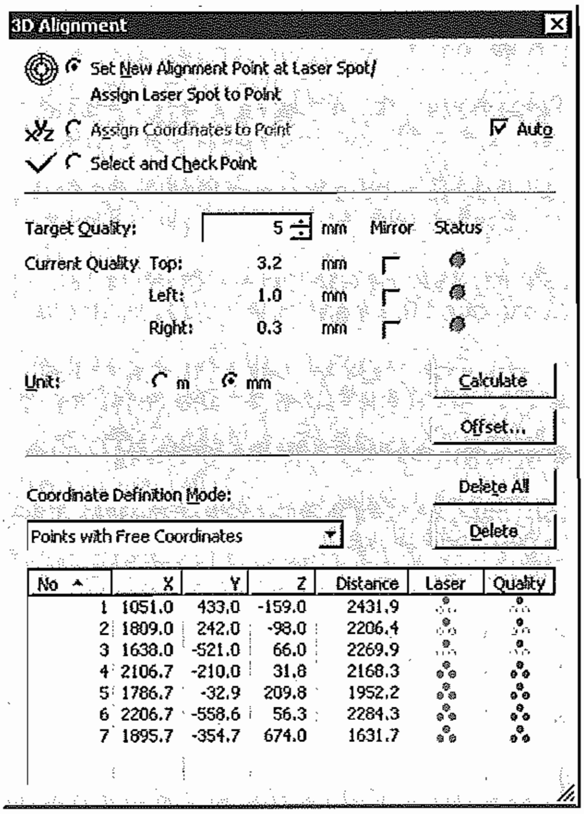


Figure 4.21: Successful 3D alignment for the PSV-3D with geometry scan unit

☞ You can sort the entries in the table in ascending or descending order in every column. To do so, click the head of the respective column.

Abort alignment

You can abort the alignment at any time. To do so, click the toolbar icon or select Setup > 3D Alignment. You will be given a message that the alignment was not finished correctly and you can now decide whether you want to repeat it or not.

Check alignment points

You can also retrospectively check the assignment of the alignment points on the video image with the coordinates in the table of the dialog 3D Alignment.

24. To do so, in the dialog 3D Alignment, select Select and Check Point.

25. Then click an alignment point in the video image. The corresponding line in the table is marked.

    Or click a line in the table. The corresponding alignment point is displayed blue in the video image.

☞ If there is valid 3D alignment, then the laser beams are moved to the positions calculated for the x-, y- and z-coordinates. You can visually check the quality of the alignment at the respective alignment point. The more accurately the laser beams hit the points on the object, the higher the quality of the alignment.

Add offset

Once you have calculated the 3D alignment, you can add an offset to the coordinates. To do so, click Offset. The dialog Add Offset appears. Enter the required offset and click OK. The offset is added to all coordinates and the alignment is calculated again.

☞ If you have selected a different coordinate definition mode than Points with Free Coordinates, then when an offset is added, the software will automatically switch into the mode Points with Free Coordinates.

End alignment

26. Click to leave the dialog 3D Alignment.

Alternative coordinate definition

Origin, Axis, Plane

To define the object coordinate system this way, replace steps 9 to 12 in section Define and assign coordinates with the following:

1. Select Origin, Axis, Plane from the list Coordinate Definition Mode.

2. With the right mouse button, click the alignment point which you want to define as origin and select Origin in the context menu. Next to the alignment point a 0 appears. The origin coordinates (0/0/0) are displayed in the dialog 3D Alignment.

3. With the right mouse button, click the alignment point which you want to define on the x-axis for example and select Point on +x-axis in the context menu. An +x will appear next to the point; an arrow will be drawn through the point. The distance and the coordinates (+x/0/0) of the point are shown in the dialog 3D Alignment.

4. With the right mouse button, click the alignment point which you want to define in a half-plane and select for example Point on x/+y plane in the context menu. An x/+y will appear next to the point. The distance and the coordinates (x/+y/0) of the point are shown in the dialog 3D Alignment.

☞ The target quality also has to be entered in this coordinate definition mode for the scanning head Top. The current quality ascertained is always 0. The target quality is used later for alignment of the scanning heads Left and Right.

5. Now continue with the 3D alignment as described from step 14 onwards further up.

Three Points on Axes

To define the object coordinate system this way, replace steps 9 to 12 in section Define and assign coordinates with the following:

1. Select Three Points on Axes from the list Coordinate Definition Mode.
2. Use the right mouse button to click the alignment point which the x-axis of the coordinate system is to run through and select Point on +x-axis in the context menu. An +x will appear next to the point; an arrow will be drawn through the point.
3. Repeat step 2 for one more alignment point each on the y- and z-axis.

☞ The target quality also has to be entered in this coordinate definition mode for the scanning head Top. The current quality ascertained is always 0. The target quality is used later for alignment of the scanning heads Left and Right.

4. Now continue with the 3D alignment as described from step 14 onwards further up.

4.5.6 Supporting out 3D Alignment with the PSV-A-PDA

To perform a 3D alignment with the optional PDA, you essentially proceed as described in SECTION 4.5.2 TO SECTION 4.5.5. You can use the PDA for the following functions:

- Selecting the scanning head
- Positioning the laser beam
- Defining alignment points
- Deleting alignment points
- Checking alignment points

Start the PDA as described in SECTION 2.9. The user interface of the PDA software appears. The icon in the menu bar tells you that you are in 3D alignment.

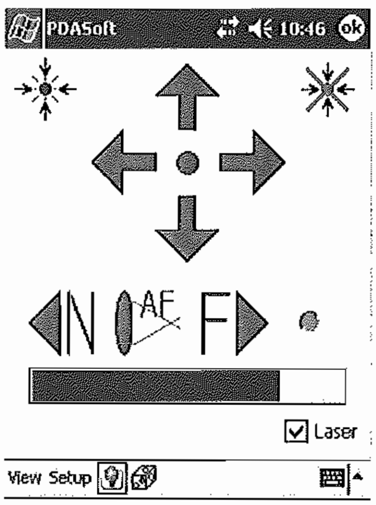


Figure 4.22: User interface of the PDA software

Select scanning head (PSV-3D)

If you are using the PSV-3D, you can select the scanning head with the PDA software.

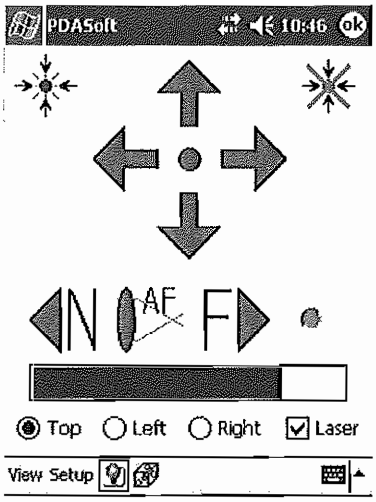


Figure 4.23: User interface of the PDA software for the PSV-3D

To select one of the three scanning heads, touch the corresponding icon Top Left Right .

Position the laser beam

Center the laser beam by touching the icon with the stylus. Position the laser beam by touching the corresponding icon for the direction , , and . .

☞ If you touch an arrow symbol for more than approx. one second, the PDA switches to fast forward. For fine adjustment you can always briefly touch the icon again.

Define alignment points

You define an alignment point by touching the icon . The software searches for the laser beam in the video image and defines an alignment point at this position. If the software does not find the laser beam in the video image, defining the alignment point fails and a corresponding message appears on the PDA.

☞ Please make sure that you yourself are not caught by the video camera, as your movement can interfere with the recognition of the laser beam.

Delete alignment points

You can delete an alignment point by positioning the laser beam on the respective point on the object under investigation and touching the icon . The software searches for the laser beam in the video image and deletes the alignment point at this position. If the software does not find the laser beam in the video image, deleting the alignment point fails and a corresponding message appears on the PDA.

☞ Please make sure that you yourself are not caught by the video camera, as your movement can interfere with the recognition of the laser beam.

Check alignment points

If there is a calculated 3D alignment available, you can check the defined alignment points with the laser beam by toggling the points on the object. To do so, proceed as follows:

1. In the software in the dialog 3D Alignment, select Select and Check Point.

2. Select View > Toggle Points in the menu bar of the PDA.

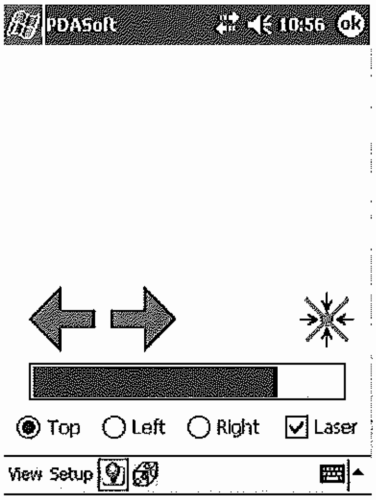


Figure 4.24: Toggle alignment points

3. Touch the icon . The laser will go directly to the coordinates of the next line of the table. Touch the icon . The laser will go directly to the coordinates of the previous line of the table. With the PSV-3D, all three lasers go directly to the coordinates.

☞ If you delete an alignment point, there is no valid 3D alignment any more and you can no longer toggle the coordinates of the alignment points.

4.5.7 3D Alignment for the MSA Scanning Head System

During 3D alignment for the scanning head system of the MSA, the coordinate system is automatically defined by the software in the scanning head system depending on the vibrational direction of the vibrometer channel.

☞ Before carrying out a 3D alignment, make sure that you have set the correct zoom factor in the list Lens in the scanning head control.

☞ If you use the MSA only with the option Data import: Geometry (ImpGeo), then you will have to import the 3D geometries after the 3D alignment. See SECTION 5.2.8 on this.
If you use the MSA-500 with the option MSAGeo, then you can instead also carry out a geometry scan. See SECTION 5.5.2 on this.

For 3D alignment, proceed as follows:

2D alignment

1. If you have not performed 2D alignment yet, do it now as described in SECTION 4.4.

☞ An automatic 3D alignment for the scanning head system is only possible if a valid 2D alignment is available.

Open dialog

2. Click or select Setup > 3D Alignment. The video window is maximized and the dialog 3D Alignment appears. You can show or hide the dialog. To do so, click or select Setup > Dialog 3D Alignment.

   You can also click the video image with the right mouse button and select Dialog 3D Alignment in the context menu. The dialog 3D Alignment appears.

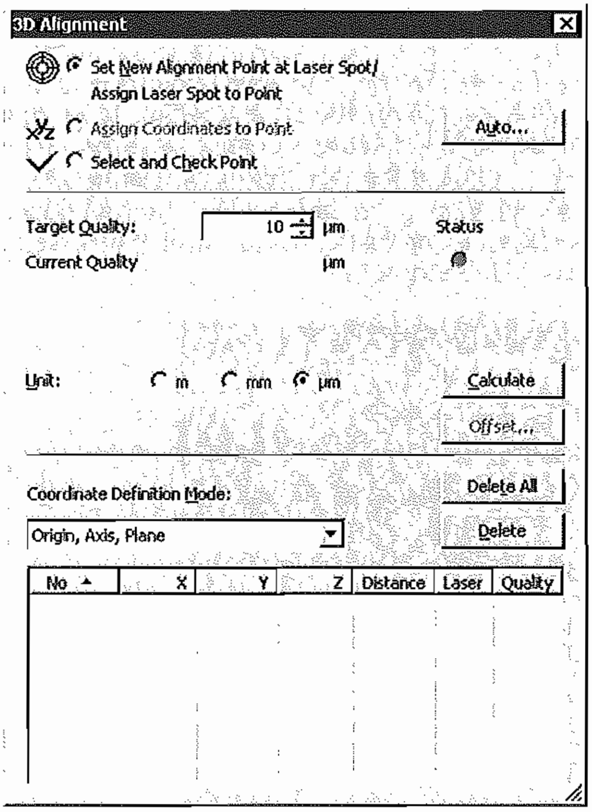


Figure 4.25: Dialog 3D Alignment for MSA-500 with the option MSAGeo (scanning head system)

Select the unit

3. Select the unit for the coordinates (m, mm or µm).

Specify quality

4. In the field Target Quality enter the maximum value by which the alignment points may deviate from the given coordinates (e.g. 10 µm).

☞ During an automatic 3D alignment, the value for the current quality is always optimized which is why an entry for the target quality does not have any influence.

Perform and calculate alignment

5. Click Auto. The coordinate definition mode is changed to Origin, Axis, Plane.

☞ If you only use the MSA with the option Data import: Geometry (ImpGeo), then the coordinate definition mode is already set to Origin, Axis, Plane and can not be changed.

6. The software then draws your attention to the fact that the vibrational direction of the vibrometer channel is used for aligning the scanning head system and that the 3D alignment is carried out and calculated automatically. Confirm this message with Yes.

☞ If you want to change the vibrational direction, click No and change the Direction of the vibrometer channel in the dialog Acquisition Settings on the page Channels (refer to SECTION 6.2.2).

The software defines the coordinate system in the scanning head system and automatically carries out the 3D alignment. The origin of the scanning head system can be found in the middle of the video image and at position D = 0 µm on the z-axis in the measurement microscope.
The software calculates the alignment. The current quality of this alignment is shown in the dialog. If the 3D alignment is successful, then the LED Status will turn green.

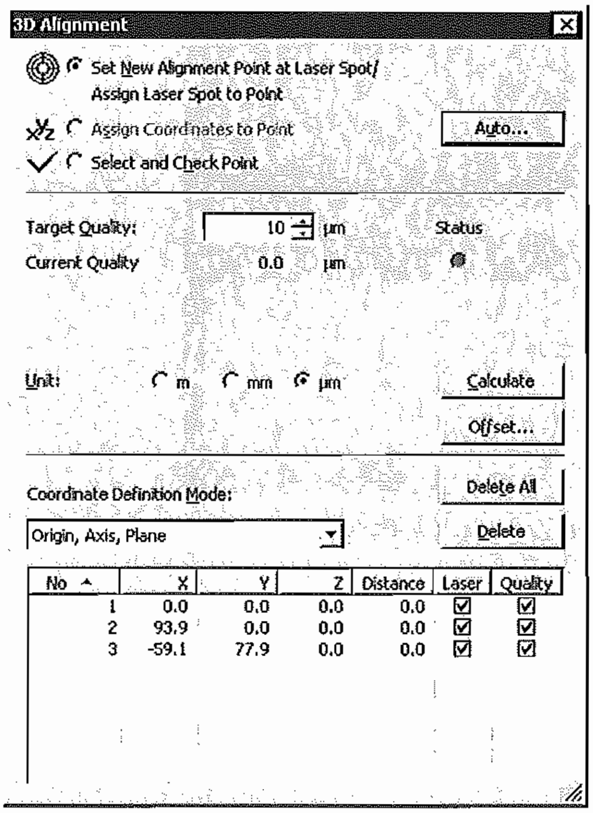


Figure 4.26: Automatic 3D alignment for MSA-500 with the option MSAGeo (scanning head system)

☞ You can sort the entries in the table in ascending or descending order in every column. To do so, click the head of the respective column.

Check alignment points

You can also retrospectively check the assignment of the alignment points on the video image with the coordinates in the table of the dialog 3D Alignment.

7. To do so, in the dialog 3D Alignment, select ✓ Select and Check Point.
8. Then click an alignment point in the video image. The corresponding line in the table is marked.

   Or click a line in the table. The corresponding alignment point is displayed blue in the video image.

☞ If a valid 3D alignment is available, then the laser beam is moved to the position calculated from the x-, y- and z-coordinates. You can visually check the quality of the alignment at the respective alignment point. The more accurately the laser beam hits the points on the object, the higher the quality of the alignment.

Delete alignment points

To delete all the alignment points, click the video image with the right mouse button and select Delete All in the context menu. You can also click Delete All in the dialog 3D Alignment.

Add offset

Once you have calculated the 3D alignment, you can add an offset to the coordinates. You will need this for example if you want to move the object for further measurements (e.g. with the optional XY positioning stage). As soon as you move the object and want to start making a new measurement, you will have to add an appropriate offset to the coordinates in the corresponding direction. To do so, click Offset. The dialog Add Offset appears. Enter the required offset and click OK. The offset is added to all coordinates and the alignment is calculated again.

☞ When adding an offset the software automatically switches to the mode Points with free Coordinates.

End alignment

9. Click to leave the dialog 3D Alignment.

4.5.8 3D Alignment for the MSA Object System

In the case of 3D alignment for the object system of the MSA, the coordinate system is defined by you in the object coordinate system. This is necessary if you want to import or respectively export geometries or want to generate combined 3D files.

☞ Before carrying out a 3D alignment, make sure that you have set the correct zoom factor in the list Lens in the scanning head control.

For 3D alignment, proceed as follows:

2D alignment

1. If you have not performed 2D alignment yet, do it now as described in SECTION 4.4.

Open dialog

2. Click or select Setup > 3D Alignment. The video window is maximized and the dialog 3D Alignment appears. You can show or hide the dialog. To do so, click or select Setup > Dialog 3D Alignment.

   You can also click the video image with the right mouse button and select Dialog 3D Alignment in the context menu. The dialog 3D Alignment appears.

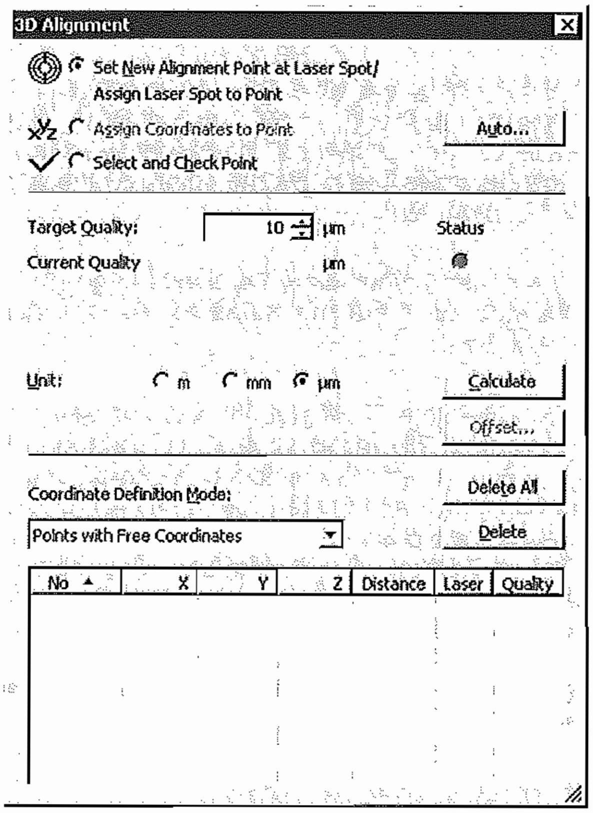


Figure 4.27: Dialog 3D Alignment for the MSA (object system)

Select the unit

3. Select the unit for the coordinates (m, mm or µm).

Position the laser beam

4. Now you can move the laser beam using the icons Position in the scanning head control.

   Alternatively you can also use the mouse directly. Using the middle mouse button (mouse wheel), click in the video image. This will make the laser beam jump to your mouse cursor. To position the beam, hold the middle mouse button pressed and drag with the mouse until the laser beam is positioned on the required point on the object.

☞ If you have assigned a special function to the middle mouse button (e.g. double-click), position the laser beam using the icons Position in the scanning head control.

   To increase the accuracy when hitting the required point, zoom the video image. See SECTION 2.6.8 on this.

Define alignment points

5. Once you have found the precise position of the required point on the object, in the dialog 3D Alignment select Set New Alignment Point at Laser Spot/Assign Laser Spot to Point. Now in the video image, click the point which the laser beam is currently at. An alignment point will now be defined there. The alignment point is marked with a black circle and a line is added to the dialog 3D Alignment which is automatically assigned to the alignment point. In the column Distance the distance measured to this alignment point is entered. In the column Laser it shows that the point has been defined.

☞ When defining each alignment point the software automatically focuses the laser beam and from the position of the z-axis in the measurement microscope, determines the coordinates of the alignment point.

6. Define three to twenty alignment points in this way. You will find information on appropriate arrangement of the alignment points in SECTION 4.6.9.

Delete alignment points

To delete an alignment point, click it in the video image with the right mouse button and select Delete in the context menu. You can also mark the corresponding line of the table in the dialog 3D Alignment and click Delete.

To delete all the alignment points, click the video image with the right mouse button and select Delete All in the context menu.

Define and assign coordinates

You have the following options to define the object coordinate system (object system):

- Points with Free Coordinates: You mark at least three points and enter all the coordinates of these points.
- Origin, Axis, Plane: You mark the origin, any point of your choice along the positive x-, y- or z-axis and any point in the positive half plane limited by the selected axis (e.g. 0, +x, x/+y).
- Three Points on Axes: You each mark any point on the positive x-, y- and z-axis.

In the following the option Points with Free Coordinates is described in detail. Both the other options will be explained to you briefly at the end of this section.

7. Select Points with Free Coordinates from the list Coordinate Definition Mode.

8. Click the alignment point with the right mouse button and select Point with Free Coordinates in the context menu. The dialog Assign Coordinates appears.

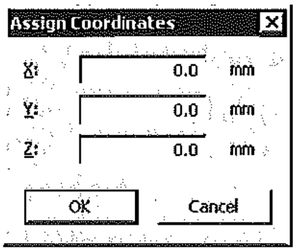


Figure 4.28: Dialog Assign Coordinates

9. Here you enter the coordinates of the alignment point and click OK. XYZ will appear next to the point.

10. Repeat steps 8 and 9 until you have assigned coordinates to at least three alignment points.

☞ If you have defined more than three alignment points, then you do not have to assign coordinates to all the alignment points. However, only alignment points which have had coordinates assigned to them will be used to calculate the 3D alignment. For further information please read SECTION 4.6.

Specify quality

11. In the field Target Quality enter the maximum value by which the alignment points may deviate from the given coordinates (e.g. 10 µm).

Calculate the alignment

Once you have defined the alignment points and have assigned coordinates to them, you can calculate the alignment.

12. Click Calculate. The software will now calculate the alignment. The current quality of this alignment is shown in the dialog. If the 3D alignment is successful, then the LED Status will turn green. If the LED lights up red, then the alignment is not valid.

☞ If the value for the current quality exceeds the value for the target quality, then a message will appear. The LED Status will turn yellow. Despite this, you can use the 3D alignment.

You can check the quality for the individual alignment points. The alignment points for which the quality value for the respective scanning head is lower than the value in the field Target Quality will have a tick in the column Quality.

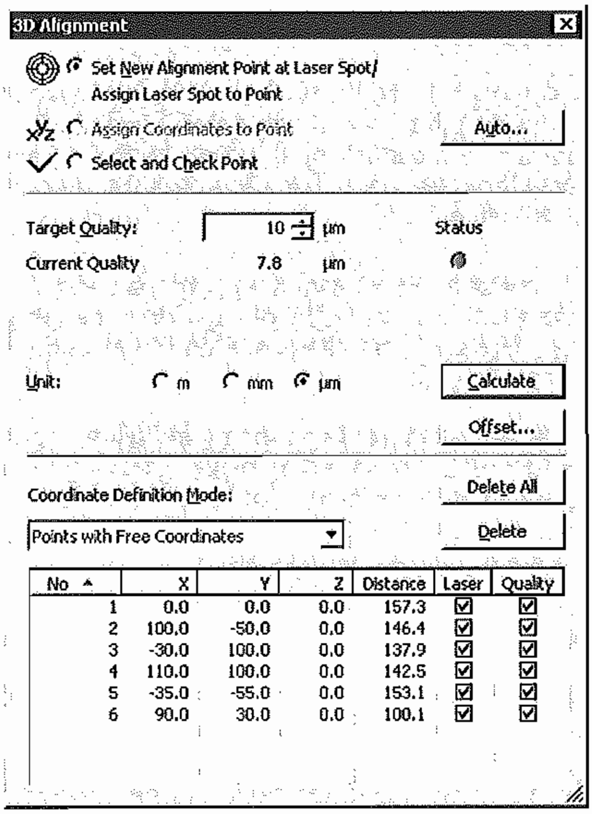


Figure 4.29: 3D alignment successfully carried out for the MSA (object system)

☞ You can sort the entries in the table in ascending or descending order in every column. To do so, click the head of the respective column.

Reassign the laser position

You can also reassign new laser positions to existing alignment points to increase the quality of the measurement results. To do so, in the dialog 3D Alignment select Set New Alignment Point at Laser Spot/Assign Laser Spot to Point. Then move the relevant laser beam to the point on the object and click the alignment point in the video image with the left mouse button. The software focuses the laser beam again and from the position of the z-axis in the measurement microscope, calculates the coordinates of the alignment point. The new position and d coordinates are used to recalculate the alignment.

Abort alignment

You can abort the alignment at any time. To do so, click or select Setup > 3D Alignment. You will be given a message that the alignment was not finished correctly and you can now decide whether you want to repeat it or not.

Check alignment points

You can also retrospectively check the assignment of the alignment points on the video image with the coordinates in the table of the dialog 3D Alignment.

13. To do so, in the dialog 3D Alignment, select Select and Check Point.
14. Then click an alignment point in the video image. The corresponding line in the table is marked.

    Or click a line in the table. The corresponding alignment point is displayed blue in the video image.

☞ If a valid 3D alignment is available, then the laser beam is moved to the position calculated from the x-, y- and z-coordinates. You can visually check the quality of the alignment at the respective alignment point. The more accurately the laser beam hits the points on the object, the higher the quality of the alignment.

Add offset

Once you have calculated the 3D alignment, you can add an offset to the coordinates. To do so, click Offset. The dialog Add Offset appears. Enter the required offset and click OK. The offset is added to all coordinates and the alignment is calculated again.

☞ If you have selected a different coordinate definition mode than Points with Free Coordinates, then when an offset is added, the software will automatically switch into the mode Points with Free Coordinates.

End alignment

15. Click to leave the dialog 3D Alignment.

Alternative coordinate definition

Origin, Axis, Plane

To define the object coordinate system this way, replace steps 7 to 10 in section Define and assign coordinates with the following:

1. Select Origin, Axis, Plane from the list Coordinate Definition Mode.
2. With the right mouse button, click the alignment point which you want to define as origin and select Origin in the context menu. Next to the alignment point a 0 appears. The origin coordinates (0/0/0) are displayed in the dialog 3D Alignment.
3. With the right mouse button, click the alignment point which you want to define on the x-axis for example and select Point on +x-axis in the context menu. An +x will appear next to the point; an arrow will be drawn through the point. The distance and the coordinates (+x/0/0) of the point are shown in the dialog 3D Alignment.
4. With the right mouse button, click the alignment point which you want to define in a half-plane and select for example Point on x/+y plane in the context menu. An x/+y will appear next to the point. The distance and the coordinates (x/+y/0) of the point are shown in the dialog 3D Alignment.
5. Now continue with the 3D alignment as described from step 11 onwards further up.

☞ The target quality also has to be entered in this coordinate definition mode. The current quality ascertained is always 0. If you have defined more than three alignment points, the excess alignment points are not taken into consideration when calculating the 3D alignment.

Three Points on Axes

To define the object coordinate system this way, replace steps 7 to 10 in section Define and assign coordinates with the following:

1. Select Three Points on Axes from the list Coordinate Definition Mode.
2. Use the right mouse button to click the alignment point which the x-axis of the coordinate system is to run through and select Point on +x-axis in the context menu. An +x will appear next to the point; an arrow will be drawn through the point.
3. Repeat step 2 for one more alignment point each on the y- and z-axis.
4. Now continue with the 3D alignment as described from step 11 onwards further up.

☞ The target quality also has to be entered in this coordinate definition mode. The current quality ascertained is always 0. If you have defined more than three alignment points, the excess alignment points are not taken into consideration when calculating the 3D alignment.

4.6 Further Information for Successful 3D Alignment

In the following sections you will receive information on how you can optimally perform the 3D alignment and what you need to take into consideration.

- Positioning Scanning Heads Appropriately, refer to SECTION 4.6.1
- Defining 3D Alignment Points with or without Geometry Scan Unit, refer to SECTION 4.6.2
- Positioning Alignment Points Appropriately, refer to SECTION 4.6.3
- Evaluating the Quality of the Alignment, refer to SECTION 4.6.4
- Editing 3D Alignment Points, refer to SECTION 4.6.5
- Receiving Optimal Results with the Geometry Scan Unit, refer to SECTION 4.6.6
- Merging Individual Measurements (Stitching), refer to SECTION 4.6.7
- Merging Individual Measurements with Mirror and Geometry Scan Unit, refer to SECTION 4.6.8
- Special Features of the MSA, refer to SECTION 4.6.9

4.6.1 Positioning Scanning Heads Appropriately (only PSV-3D)

For the PSV-3D, it is important to position the scanning heads in such a way that a 3D signal can be calculated from the signals from the three scanning heads. Ideally you position the three scanning heads in front of the object arranged as an equilateral triangle. If it is not possible to do this precisely, change the angles slightly. Avoid all three laser beams being in one plane. For all measurement points the following must apply: Every laser beam must clearly project from the plane through which the other two laser beams are mounted.

For surfaces which scatter diffusely, such as white tear testing spray or reflective film you will attain optimal results if every laser beam hits the surface at an angle of approx. 40° to the surface normal. For surfaces with partially directional backscattering (e.g. processed metal surfaces, car paints), an angle of approx. 20° to the surface normal is optimal.

Please make sure that all measurement points can be reached by all scanning heads respectively. For very jagged objects it may be necessary to deviate from the optimal angle or several measurements will have to be made from different positions and then be collated afterwards.

For small measurement surfaces we recommend setting up the distance of the scanning heads to the center of the object in such a way that the scanning heads are at a visibility maximum. However, should the distance across the measurement surface change more for larger measurement objects than the distance between two visibility maxima (204 mm, refer also to theory manual), then this recommendation does not make any sense. In this case you should select the smallest possible distance which you need to reach the whole area of interest with the laser beam.

4.6.2 Defining 3D Alignment Points with or without Geometry Scan Unit

If you have a scanning head with the geometry scan unit PSV-A-420 available, you can choose whether you want to use the geometry scan unit for 3D alignment or not.

Generally we recommend using the geometry scan unit for 3D alignment. It makes it easier to carry out 3D alignment and the accuracy requirements of the coordinates of the points on the object under investigation are lower. The geometry scan unit also allows 3D alignment if no points with known coordinates are available.

With the PSV-3D it can be advantageous to work without an activated geometry scan unit. This is the case if the laser beams are to provide very good cover on small objects (size of area of interest approx. 1...10cm). Here the information on selecting the alignment points as described in SECTION 4.6.3 is very important. For small or flat objects it can be useful to perform the 3D alignment without an activated geometry scan unit but using a larger replacement object on which points with precisely measured coordinates are marked. After finishing 3D alignment, the object is positioned in place of the replacement object.

4.6.3 Useful Positioning of Alignment Points (PSV/PSV-3D)

☞ In this section, the points on the object which are used for alignment are called alignment points.

Your selection of alignment points depends on whether you are performing 3D alignment with or without the geometry scan unit. If you are performing 3D alignment with the PSV-3D with an activated geometry scan unit, then the following recommendations for 3D alignment with the geometry scan unit only apply for the scanning head Top which the geometry scan unit is installed on.

As it is not possible to attach geometry scan units to the scanning heads Left and Right, the distances between these scanning heads and the points on the object can not be measured. For these scanning heads, the recommendations for 3D alignment without geometry scan unit always apply.

☞ When selecting the alignment points, make sure that the scanners in the scanning heads always use optimal linearity at an angle of around ±12°. This angle range should be used as well as possible. Larger angles should be avoided where possible.

PSV-3D with geometry scan unit		
Scanning head Top	Scanning head Left	Scanning head Right
Read further information on: Appropriate Alignment Points for the 3D Alignment **with** Geometry Scan Unit	Read further information on: Appropriate Alignment Points for the 3D Alignment **without** Geometry Scan Unit	

Appropriate Alignment Points for the 3D Alignment with Geometry Scan Unit

If you are working with the geometry scan unit, the laser angles set and the distances measured are used to calculate the position and orientation of the scanning head. At least three alignment points are necessary for 3D alignment. The alignment points have been optimally selected if the surface of the triangle formed by these points in space is as large as possible.

So it is particularly important that the alignment points in three-dimensional space are not along one line. In this case, the surface of the triangle formed would be zero. Despite this, the software can successfully calculate 3D alignment. The calculated position of the scanning head however is then one of any number of solutions and thus undefined.

When using the coordinate definition mode Points with Free Coordinates you can set up to twenty alignment points with free coordinates. By setting additional alignment points, errors in the coordinates when positioning the laser and making the distance measurement have less effect on the results of the 3D alignment. Setting additional alignment points is particularly recommended if the uncertainty of the coordinates is greater than 1 mm.

Appropriate Alignment Points for the 3D Alignment without Geometry Scan Unit

If you deactivate the geometry scan unit, the laser angles set are used to calculate the position and orientation of the scanning head. The distances between the scanning head and the points on the object are unknown and can not contribute towards calculating the 3D alignment. For this reason, without a geometry scan unit, three alignment points are not enough; you will have to define at least four alignment points.

☞ The following information on defining appropriate alignment points also applies to the scanning heads Left and Right of the PSV-3D if the geometry scan unit on the scanning head Top is activated for 3D alignment.

The selection of the four alignment points for 3D alignment is virtually optimal if the volume of the tetrahedron they form is as large as possible. Here, arrangements in which the point of the tetrahedron points in the direction of the scanning heads is advantageous in comparison to arrangements in which the point of the tetrahedron points away from the scanning heads.

If the alignment point are arranged unfavorably, then this can lead to ambiguous solutions. In particular if all the alignment points with the point at which the laser is emitted from the scanning head can form an imaginary cylinder together, then the calculated position of the scanning head is one of many possible solutions and thus undefined. This is then also virtually the case if all alignment points are on one plane which is small in comparison to its distance from the scanning head.

You can define up to seven alignment points for 3D alignment. By defining additional alignment points, errors in the coordinates and from positioning the laser have less effect on the results of the 3D alignment. Additional alignment points are always an advantage if the 3D alignment needs to be particularly precise. This is in particular the case with the PSV-3D because here the results of the 3D alignment are not only needed for positioning the laser but also for the coordinate transformation of the measurement values.

With the PSV-3D you can perform 3D alignment for the scanning head Top with the geometry scan unit. After that, the alignment points for scanning heads Left and Right can be set advantageously. As alignment of scanning heads Left and Right has been preceded by a 3D alignment for the scanning head Top, any points in the coordinate system of the object can be measured. This means that alignment points can be used for the 3D alignment which are not on the measurement object. In particular for the point of the tetrahedron, a replacement object can temporarily be placed between the object and the scanning heads. For small objects, additional alignment points can be defined on a replacement object behind the object under investigation.

4.6.4 Evaluating the Quality of the 3D Alignment (PSV/PSV-3D))

The Current Quality shown in the dialog 3D Alignment is a measure of how well the given alignment points can be hit again with the aid of their coordinates, the position calculated in 3D alignment and the orientation of the scanning head. On its own, the current quality displayed does not provide any information on how well it has been possible to reconstruct the position of the scanning head in the object's coordinate system through 3D alignment.

Example: With 3D alignment with the geometry scan unit, the three alignment points are approximately in a line. As described in SECTION 4.6.3, no clear solution for the scanning head position is found when calculating the 3D alignment. Despite this, a lower value is shown for the current quality because from the results of the 3D alignment, the given points on the object under investigation can be hit very accurately.

A lower value for the displayed quality of the 3D alignment is thus only an indicator for high quality if, when selecting the alignment points, the advice in SECTION 4.6.3 has been followed.

You will find another way to evaluate the quality of the 3D alignment in the 3D view. There you can display the scanning head position relative to the geometry. To do so, activate in the dialog Display Properties on the page 3D View the check box Scan Range (refer to SECTION 8.1.3). The software shows the position of the scanning head with the aid of stylized laser beams at the four positions with maximum angle (x ±20°; y ±20°). With the PSV-3D, the positions of all three scanning heads are shown.

☞ The page 3D View is only displayed if you have defined scan points.

For the PSV-3D, you can calculate the distance of the scanning heads to each other with the aid of the macro ScanHeadPositions.bas. Then using a measuring tape you can evaluate whether the distances that are calculated via the 3D alignment correspond with the reality.

4.6.5 Editing 3D Alignment Points

3D alignment points that have already been defined can be edited. In doing so you can:

- define object system alignment points as alignment points.
- change the coordinate definition mode.
- modify coordinates of the alignment points in definition mode Points with Free Coordinates.

Defining Object System Alignment Points as Alignment Points

To define an object system alignment point (an alignment point defined with the aid of a coordinate definition mode) as a normal alignment point, click it with the right mouse button and select Alignment Point in the context menu. The alignment point remains but it is no longer an object system alignment point, see also SECTION 4.5.3, SECTION 4.5.5or SECTION 4.5.8 on this. The special identification which identifies it as an object system alignment point disappears as well.

Changing Coordinate Definition Mode

Independently of which coordinate definition mode you have defined the alignment points in (Points with Free Coordinates; Origin, Axis, Plane; Three Points on Axes), you can still retrospectively change the definition mode. To do so, proceed as follows:

1. In the dialog 3D Alignment, select another definition mode. The object system alignment points become alignment points without identification. If a valid 3D alignment had already been carried out however, the coordinates of the alignment points are retained.

2. Click the alignment point you want to edit with the right mouse button and select the corresponding command in the context menu (refer also to SECTION 4.5.3, SECTION 4.5.5or SECTION 4.5.8).

Modifying Coordinates of Alignment Points with Free Coordinates

To modify free coordinates of alignment points which have already been set, proceed as follows:

1. Click an alignment point with the right mouse button and select Point with Free Coordinates in the context menu. The dialog Assign Coordinates appears (refer also to FIGURE 4.12).
2. Here you enter the correct values and click OK.

4.6.6 Receiving Optimal Results with the Geometry Scan Unit

The distance is measured between the scanning head and the point which the laser is aimed at with the aid of the geometry scan unit. The geometry scan unit needs enough light scattered back for it to provide optimal results. To ensure this, proceed as follows:

1. Switch the geometry laser on. To do so, select Scan > Geometry Laser.
2. If the LED OVER displays overload of the measurement range in the scanning head control, switch the filter on. To do so, click the box Filter in the scanning head control.

☞ If you are using a geometry scan unit with a toggle switch FILTER, switch on the filter on the geometry scan unit (refer to hardware manual).

3. Watch the signal level in the scanning head control. The signal level should make up at least one third of full scale.

With a low signal level, interference reflection from the optics in the beam path can cause distances measured to be too short. The threshold below which these measurement errors actually occur is generally around a signal level of 10%. It varies slightly from instrument to instrument and depends on how dirty or clean the optics are. The reason for this is that the geometry laser in contrast to the vibrometer laser does not work with a focused laser beam and is therefore influenced by all reflections which appear in the beam path.

☞ A third of full scale is usually attained at distances of up to 3 m, measured on a white surface which scatters diffusely. Keep to this signal level for 3D alignment and then you will be sure not to get a measurement error in the distance measurement.

4.6.7 Merging Individual Measurements (Stitching)

With the aid of 3D alignment, measurement objects from several positions can be acquired and the individual results can be combined retrospectively. As you move the scanning heads or the object between the individual measurements, you have to perform a 3D alignment in the new position again.

Without a geometry scan unit, the laser beams have to be able to hit at least four alignment points with known coordinates for every measurement segment. This can be done for example in advance of the measurement with the aid of a coordinate measurement device.

With a geometry scan unit you have the option of measuring points for the next measurement segment at the edge of the respective measurement segment. To do so, define alignment points which are not marked as object system alignment points. After 3D alignment has been calculated, the coordinates of these alignment points are displayed in the dialog 3D Alignment, however they are not used for calculating this 3D alignment.

In the case of the PSV-3D with a geometry scan unit, it is advantageous if you do not change the relative position of the scanning heads. You can reach this e.g. with the aid of an optional tripod at which all three scanning heads are mounted on one holder or by moving the object under investigation. In this case you will only have to redo the 3D alignment for the scanning head Top. 3D alignment for the scanning heads Left and Right remains valid. This is because the coordinates of the alignment points from the scanning heads Left and Right are calculated from the new position of the scanning head Top. At the same time the previously measured distances from the scanning head Top and thereby the adjusted mirror angles of the scanning head Top enter the calculation. The alignment points changed that way have thus the same position relative to the scanning head Top as they have before. Using these changed coordinates, the positions of the scanning heads Left and Right will then be recalculated. In doing so, the previously adjusted mirror angles of these scanning heads enter the calculation. Summarized, this means that the scanning heads Left and Right are at the same position relative to the scanning head Top as they are before. But relative to the object, all three scanning heads are moved.

☞ Please note that using this procedure the alignment points of the scanning heads Left and Right are no longer situated on the object. Therefore, at these coordinates the laser beams do no longer hit each other on the object as well. In this case, you can ignore this.

4.6.8 Merging Individual Measurements with Mirror and Geometry Scan Unit

If you want to measure two sides of an object, then you can measure one side directly and the other side with the aid of a mirror. To do so, proceed as follows:

1. Mark points on the surface of the mirror. This can be done with surface mirrors, for example by putting stickers on the corners of the mirror.
2. Perform a 3D alignment directly on the object with the aid of the geometry scan unit (i.e. without using the mirror).
3. Define at least three corners of the mirror as alignment points.
4. Calculate 3D alignment. This will determine the coordinates of the points marked on the mirror. However, these coordinates will not be used for 3D alignment.
5. If necessary, change to coordinate definition mode Points with Free Coordinates.
6. Define the alignment points on the surface of the mirror as Points with Free Coordinates.
7. Delete the original object system alignment points which you defined directly on the object.

8. Now you can calculate 3D alignment for the measurement via mirrors by marking the box Mirror and recalculating the 3D alignment.

☞ With the PSV-3D you have to mark the box Mirror for all three scanning heads respectively. If you have performed 3D alignment for the scanning heads Left and Right as described in SECTION 4.5.5, then you do not have to do anything other than recalculate the 3D alignment. This is because the relative position of the scanning heads to each other is not changed. Thus the same applies as already described in SECTION 4.6.7.

4.6.9 Special Features of 3D Alignment with the MSA

☞ In this section, the points on the object which are used for alignment are called alignment points.

Position alignment points appropriately

If you are working with the MSA-500 and the option MSAGeo, then the laser position and the position of the z-axis in the measurement microscope are used to calculate the position and orientation of the object coordinate system. At least three alignment points are necessary for 3D alignment. The alignment points have been optimally selected if the surface of the triangle formed by these points in space is as large as possible.

So it is particularly important that the alignment points in three-dimensional space are not along one line. In this case, the surface of the triangle formed would be zero. Despite this, the software can successfully calculate 3D alignment. The calculated position of the object coordinate system however is then one of any number of solutions and thus undefined.

When using the coordinate definition mode Points with Free Coordinates you can set up to twenty alignment points with free coordinates. By setting additional alignment points, errors in the coordinates when positioning the laser and the z-axis have less effect on the results of the 3D alignment. Setting additional alignment points is particularly recommended if the uncertainty of the coordinates is greater than 10 µm.

Merging Individual Measurements

With the aid of 3D alignment, areas of large measurement objects can be acquired one after the other and the individual results can be combined retrospectively. As you move the scanning heads or the object between the individual measurements, you have to perform a 3D alignment in the new position again.

☞ A new 3D alignment is not necessary if you can move the object with the aid of an offset.

5 Defining Scan Points (APS)

Before a scan you first of all have to define the scan points. To do so, you draw geometrical figures on the live video image as you would in graphics software. The software offers the following functions for this:

Standard Mode, refer to SECTION 5.1

Point Mode (optional), refer to SECTION 5.2

Common Functions in Both Modes, refer to SECTION 5.3

Editing Scan Points (not APS), refer to SECTION 5.4

Carrying out Geometry Scan (optional), refer to SECTION 5.5

Teaching-in Focus Values (optional), refer to SECTION 5.6

Standard mode

In standard mode you can draw rectangles, ellipses, polygons and lines. You can set up the grid for every figure individually and it can also be polar or hexagonal.

Point mode (as an option)

In point mode you do not draw figures but define and edit single scan points and their connections. You can take over scan point definitions from the standard mode and fine-tune them. Point mode is only available if you have the option APS Professional. In point mode you can define scan points with both the PSV software and also the optional PDA. See SECTION 5.2.1 or SECTION 5.2.2 on this.

☞ With the PSV or the PSV-3D (1D), 2D geometries are created in standard and point mode (refer also to SECTION 3.1). With a valid 3D alignment you can also import 3D geometries.

In point mode for PSV-3D, you can import scan points from an external file or teach them in with the aid of the three scanning heads. This is also possible with the PSV if you use the optional geometry scan unit.

If you are using a scanning head with the geometry scan unit, you can proceed as follows:

1. Define the scan points in standard or point mode as described in SECTION 5.1 or SECTION 5.2 respectively.
2. Exit scan point definition and carry out a geometry scan as described in SECTION 5.5.
3. Go to point mode. In doing so, the scan points and the measured coordinates are retained.

The following table contains an overview of the geometries which you can define with the PSV, PSV-3D, MSA, and the UHF.

System	Standard	Standard with geometry scan unit	Point	Point with geometry scan unit	Point with geometry import
PSV	2D	3D	2D	3D	3D
PSV-3D (3D)	3D	3D	3D	3D	3D
PSV-3D (1D)	2D	3D	2D	3D	3D
MSA	2D	-[1]	2D	-[1]	3D
UHF	2D	-	2D	-	-

[1] You can define 3D geometries for the MSA-500 with the option MSAGeo.

Define

To define scan points, proceed as follows:

1. Go into acquisition mode. To do so, click .
2. If necessary, align the positions on the live video image with the position of the laser on the measurement plane or perform a 3D alignment. See SECTION 4.4 or SECTION 4.5 on this.
3. In the toolbar of the application window, click or select Setup > Define Scan Points. The software maximizes the video window and displays a graphics toolbar. Areas of the live video image can be crosshatched. These areas are outside the range you can scan.

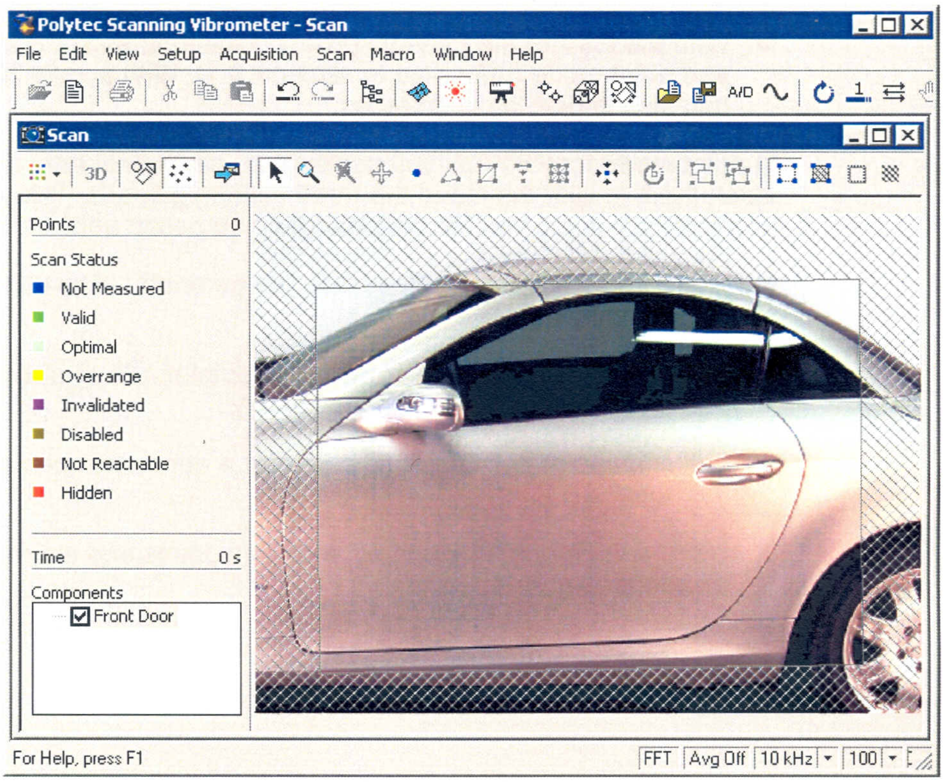


Figure 5.1: Available range for defining the scan points

☞ The possible scan area depends on the scanning head, zoom of the camera and correct 2D or 3D alignment respectively.

4. Go to the required mode.

   To scan a flat object, click (standard mode) or (point mode) in the graphics toolbar. Point mode is only available if you have the option APS Professional.

5. Define scan points as described in SECTION 5.1 and SECTION 5.2. You can see how many scan points you have defined in the legend of the live video image. Below that you see the estimated time needed for the scan. The estimation is based on the time for data acquisition at all scan points and the settling time of the scanner mirrors.

☞ You can also define scan points in the crosshatched area of the live video image. However, when scanning, these scan points themselves are not hit, but the next attainable point respectively.

6. If you have defined all the scan points, click in the toolbar of the application window again to quit scan point definition.

Zoom

To position the scan points exactly, you can zoom in the video image. Read SECTION 2.6.8 on this.

Test

As the live video image shows a two-dimensional image of the three-dimensional object, it is possible that the laser beam does not hit some of the scan points exactly. So check the scan points as follows:

7. Point at the live video image and click a scan point. The laser beam moves to this point on the object.

   Only PSV-400: You can also approach the scan points with the optional PSV-A-PDA or the hand set PSV-Z-051. See SECTION 5.2.2 and your hardware manual on this.
   Only PSV-300: You can also position the laser beam on scan points using the hand set PSV-Z-051. See your hardware manual on this.

8. Check if the position of the laser beam on the object corresponds to that on the live video image.

9. Repeat steps 7 and 8 for a few more scan points.

5.1 Standard Mode

In standard mode you draw geometric figures. While doing so, you can use following functions:

- Drawing Lines, refer to SECTION 5.1.1
- Drawing Rectangles and Squares, refer to SECTION 5.1.2
- Drawing Ellipses and Circles, refer to SECTION 5.1.3
- Drawing Polygons, refer to SECTION 5.1.4
- Rotating Figures, refer to SECTION 5.1.5 and changing their shape, refer to SECTION 5.1.6
- Distributing Scan Points among Figures, refer to SECTION 5.1.7
- Setting up the Grid for Each Figure Individually, refer to SECTION 5.1.8
- Defining Vertex Points of Ellipses, refer to SECTION 5.1.9
- Setting Properties of Lines, refer to SECTION 5.1.10

To go to standard mode, in the graphics toolbar, click . The dialog Object Properties appears.

☞ If you define scan points with the PSV-3D in standard mode, then these points have already have 3D coordinates assigned to them. These coordinates have been calculated from the preceding 3D alignment of the three scanning heads and their mirror angles. It is not possible to make a calculation of this kind with the PSV or PSV-3D (1D). To be able to obtain 3D data with the PSV or PSV-3D (1D) despite this, you have to import the data in point mode or determine it using the geometry scan unit.

5.1.1 Drawing Lines

To draw a line, proceed as follows:

1. Click .
2. Point at the live video image. The cursor becomes a cross.
3. Click the corners of the line.
4. Double-click the last corner.

5.1.2 Drawing Rectangles and Squares

To draw a rectangle or a square, proceed as follows:

1. Click .
2. Point at the live video image. The cursor becomes a cross.

Rectangle

There are two ways of drawing a rectangle:

3. Point at a corner of the rectangle.
4. Press the mouse button and drag to the diagonally opposite corner.

or

5. Point at the center of the rectangle.

6. Press the control key and the mouse button simultaneously and drag across to a corner point.

Square There are two ways of drawing a square:

7. Point at a corner of the square.

8. Press the shift key and the mouse button simultaneously and drag to the diagonally opposite corner.

or

9. Point at the center of the square.

10. Press the control key, shift key and the mouse button simultaneously and drag across to a corner point.

5.1.3 Drawing Ellipses and Circles

To draw an ellipse or a circle, proceed as follows:

1. Click ⬭.

2. Point at the live video image. The cursor becomes a cross.

Ellipse There are two ways of drawing an ellipse:

3. Point at a corner of the rectangle enclosing the ellipse.

4. Press the mouse button and drag to the diagonally opposite corner.

or

5. Point at the center of the ellipse.

6. First press and hold the control key and then the mouse button and drag across to a corner point of the rectangle enclosing the ellipse.

Circle There are two ways of drawing a circle:

7. Point at a corner of the square enclosing the circle.

8. First press and hold the shift key and then the mouse button and drag to the diagonally opposite corner.

or

9. Point at the center of the circle.

10. Press the control key, shift key and the mouse button simultaneously and drag across to a corner point of the square enclosing the circle.

5.1.4 Drawing Polygons

To draw a polygon, proceed as follows:

1. Click .
2. Point at the live video image. The cursor becomes a cross.
3. Click at least three corners of the polygon.
4. Double-click the last corner. The software connects it to the first corner.

5.1.5 Rotating Figures

To rotate figures, proceed as follows:

1. Select the figures as described in SECTION 5.3.2.

There are now two ways of rotating figures:

2. In the dialog Object Properties you enter the absolute angle of rotation in the field Rotation of the group Object.

or

3. Click .
4. Point at one of the white markers which mark the edge of the figures. The cursor becomes a .
5. Press the mouse button and drag in the direction you want to rotate in. The anchor point is the center of the figures.

5.1.6 Changing the Shape of a Figure

You can retrospectively insert corners in figures and move corners individually. To do this, proceed as follows:

1. Select the figures as described in SECTION 5.3.2.
2. Click .

To insert a corner:

3. Point at the edge of the figure. The cursor becomes a .
4. Click the edge of the figure. The software inserts a corner point at this place.

To move a corner point:

5. Point at the corner. The cursor becomes a .
6. Press the mouse button and drag in the direction required.

5.1.7 Distributing Scan Points among Figures

Using the icons , , and in the dialog Object Properties you can distribute scan points among figures. To do this, first select the figures as described in SECTION 5.3.2. Then click

: You are defining scan points inside and on the edges of the figures (not active for lines).

: You are defining scan points only within the figures (not active for lines).

: You are only defining scan points on the edges of the figures.

: You are deleting the scan points inside and on the edges of the figures.

5.1.8 Setting up the Grid

In standard mode, every figure has got its own grid. To set up the grid, first of all select the figure as described in SECTION 5.3.2. In the dialog Object Properties you can then

- select the type of grid
- set the density of the grid points
- rotate the grid.

You can not set up a grid for lines and figures which only have scan points on the edge (refer to SECTION 5.1.7).

Type of grid

To select the type of grid, click

for a right-angled grid,

for a polar grid or

for a hexagonal grid.

Density of grid points

You enter the density of the grid points in the dialog Object Properties in the respective fields Density. You can also enter decimals. The density is independent of the dimensions of the figure, it always refers to the height of the live video image.

For a figure with a right-angled grid, in the dialog the fields Density X and Density Y appear. The density of the grid points $d_{x,y}$ determines the distance between the grid points $a_{x,y}$ as follows:

$$a_{x,y} = \frac{h_y}{d_{x,y}} \qquad \text{Equation 5.1}$$

h_y... Height of the live video image.

For a figure with a polar grid, the fields Density radial and Density tang appear. The radial density d_{radial} determines the distance between the grid points on the beams a_{radial} as follows:

$$a_{radial} = \frac{h_y}{d_{radial}} \qquad \text{Equation 5.2}$$

h_y... Height of the live video image.

The tangential density d_{tang} is equal to the number of grid points on the circles.

For a figure with a hexagonal grid, the field Density appears. The density of the grid points d determines the distance between neighboring grid points as follows:

$$a = \frac{h_y}{d} \qquad \text{Equation 5.3}$$

h_y... Height of the live video image.

Rotate grids

You can rotate a grid relatively to its figure. To do so, enter the angle of rotation in the field Rotation of the group Grid.

5.1.9 Defining Vertex Points of Ellipses

The software approximates ellipses by using polygons (at least quadrangles). You can set the number of vertex points. To do this, first select the ellipse as described in SECTION 5.3.2. In the dialog Object Properties, the field Vertex Points then appears, in which you can enter the required number of vertex points. The number of vertex points then also applies for all ellipses which you subsequently draw.

☞ If you define scan points on the edge of an ellipse (refer to SECTION 5.1.7), every vertex point becomes a scan point.

5.1.10 Setting Properties of Lines

Lines and figures which only have scan points on the edge (refer to SECTION 5.1.7) do not have a grid. However, you can set the density of the scan points on the lines. To do this, first select the figure as described in SECTION 5.3.2.

Resolution In the dialog Object Properties, the field Resolution appears. Here you enter a value. This value reflects the number of scan points on one line, the length of which corresponds to the height of the video image. This also applies to rectangles, polygons and ellipses whose scan points are only on the edge.

Width For lines, the field Width also appears. The width determines the size of a shadow around the line. Within the shadow, the scan points that are behind the line are hidden. This means, for example, you can delete scan points on cables which obscure the view of the object.

5.2 Point Mode (as an Option)

Point mode is only available if you have the option APS Professional. In point mode you do not draw figures but edit single scan points and their connections. While doing so, the following functions are available to you:

- Defining Single Scan Points using the Software, refer to SECTION 5.2.1
- Defining Single Scan Points using the Optional PSV-A-PDA, refer to SECTION 5.2.2
- Defining Connections between Scan Points, refer to SECTION 5.2.3
- Deleting Connections, refer to SECTION 5.2.4
- Refining the Scan Point Grid, refer to SECTION 5.2.5
- Coarsen the Scan Point Grid, refer to SECTION 5.2.6
- Merging Scan Points in the Grid, refer to SECTION 5.2.7
- Importing Scan Points, refer to SECTION 5.2.8
- Teaching-in Scan Points with the Geometry Scan Unit, refer to SECTION 5.2.9
- Defining Scan Points with Auto Align, refer to SECTION 5.2.10
- Editing Scan Points, refer to SECTION 5.2.11

Take over scan point definition You can take over scan point definitions from the standard mode and fine-tune them. To do so, proceed as follows:

1. Draw figures in standard mode as described in SECTION 5.1.
2. Go to point mode. To do so, in the graphics toolbar, click ∴. A message window appears. To separately save the scan points which have already been defined and to then define new ones, click Save. To add more to those which already exist, click Continue.

☞ If you have the project browser displayed (refer to SECTION 2.6.4), you will then automatically be shown the directory marked there as saving location.

3. Click Continue. The software groups all scan points which have already been defined and selects the group.

4. Undo grouping. To do so, click . The software selects all scan points.

5. Undo the selection. To do so, click the live video image outside the scan points.

6. You can now edit scan points as described in SECTION 5.2.11. Apart from that, you can define single scan points as described in SECTION 5.2.1 and SECTION 5.2.2.

   Only PSV-400: You can also approach the scan points with the optional PSV-A-PDA or the hand set PSV-Z-051. See SECTION 5.2.2 and your hardware manual on this.
   Only PSV-300: You can also position the laser beam on scan points using the hand set PSV-Z-051. See your hardware manual on this.

7. You can edit connections of scan points as described in SECTION 5.2.3 and SECTION 5.2.4.

Additional functions

If you have performed 3D alignment (refer to SECTION 4.5) respectively, you have also following possibilities to define scan points:

- Importing scan points (PSV-3D or optional for PSV and MSA). See SECTION 5.2.8 on this.
  If you know the geometry of the object and it is saved in an external program, you can simply import the required scan points as a Universal File. You can also import Vibrant ME'Scope structural data and ASCII data. For this purpose, an additional file filter is available in the dialog Open. See also SECTION 10.1.5 on this.
- Teaching-in scan points with the geometry scan unit PSV-A-420 (only PSV-3D or as an option for PSV) See SECTION 5.2.9 on this.
  If there is no data available on the object, you can define the scan points yourself. See also in SECTION 5.2.1 and following on this.
- Defining scan points with Auto Align. See also SECTION 5.2.10 on this.

☞ If you change from standard mode into point mode, scan points that have already been defined remain.

5.2.1 Defining Single Scan Points using the Software

There are two ways of defining a scan point:

1. Click .

2. Point at the live video image and click. A scan point is defined at this place.

or>

1. Move the laser beam on the object to the point at which you want to define a scan point. See SECTION 4.1 on this.

2. Click .

5.2.2 Defining Single Scan Points using the PSV-A-PDA (as an Option)

You can use the optional PDA to help you define single scan points. To do so, proceed as follows:

1. Go to point mode. To do so, in the graphics toolbar, click ⁘.
2. Start the PDA as described in SECTION 2.9. The user interface of the PDA software appears. You identify being in scan point definition with the icon in the menu bar.

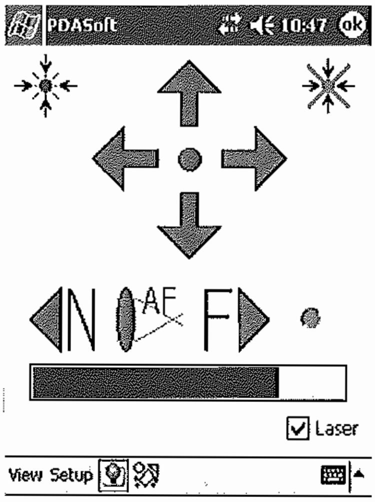


Figure 5.2: User interface of the PDA software

Position the laser beam

3. Center the laser beam by touching the icon ● with the stylus.
4. Position the laser beam by touching the icons ⬇, ⬆, ⬅ and ➡.

☞ If you touch an arrow symbol for more than approx. one second, the PDA switches to fast forward. For fine adjustment you can always briefly touch the icon again.

Define scan points

5. You define a scan point by touching the icon.

Delete scan points

6. You can delete a scan point by positioning the laser beam on a scan point and touching the icon.

Toggle scan points

You can use the optional PDA to toggle defined scan points with the laser beam. To do so, proceed as follows:

1. Select View > Toggle Points in the menu bar of the PDA.

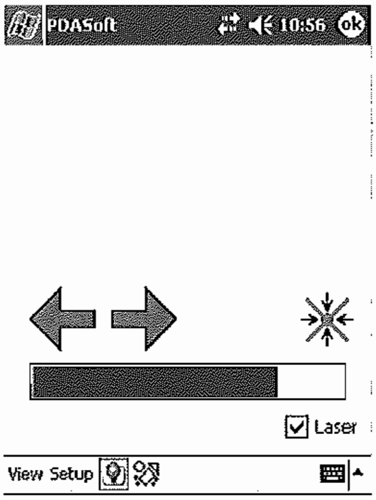


Figure 5.3: Toggle scan points

2. Touch the icons or . The laser will toggle the defined scan points backwards or forwards.

Select the scanning head (PSV-3D)

If you are using the PSV-3D, you can also select the scanning heads with the PDA software.

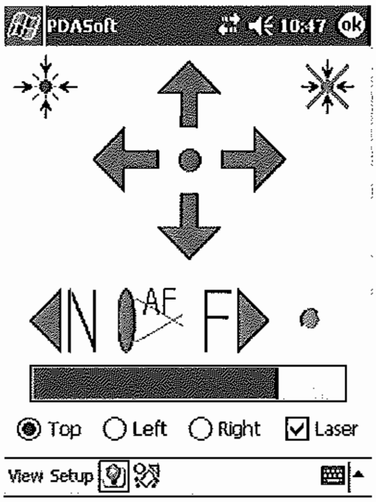


Figure 5.4: User interface of the PDA software for the PSV-3D

To select one of the three scanning heads, touch the corresponding icon Top Left Right .

You can define and delete the scan points for every scanning head as described above.

5.2.3 Defining Connections between Scan Points

There are several ways of connecting scan points.

- Connect two scan points and thus define a line.
- Connect three scan points and thus define a triangle.
- Automatically connecting selected scan points with each other.

☞ In point mode it is useful to select the view (refer also to SECTION 5.3.2). You can then see which areas are enclosed by scan points.

Connect two scan points

To connect two scan points, proceed as follows:

1. Click .
2. Point at the first scan point. The cursor becomes a cross.
3. Click the scan point.
4. Point at the second scan point.
5. Double-click.

Connect three scan points

To connect three scan points, proceed as follows:

1. Click .
2. Point at the first scan point. The cursor becomes a cross.
3. Click the scan point.
4. Point at the second scan point and click.
5. Point at the third scan point and click. The software connects this scan point to the first one.

Connect selected scan points

To connect selected scan points, proceed as follows:

1. Select the points you want to connect as described in SECTION 5.4.1.
2. Click . The software connects all selected scan points so that triangles are created.

Connect scan points automatically

You can also connect scan points automatically. As a condition you have to take the following into consideration:

- You must be in APS point mode (only with option APS Professional).
- You have to change to 3D View.

☞ You can also automatically connect scan points in presentation mode.

To automatically connect scan points, proceed as follows:

1. In the toolbar of the application window, click or select Setup > Define Scan Points. The software maximizes the video window and displays a graphics toolbar.

2. In the graphics toolbar click (point mode). Point mode is only available if you have the option APS Professional.

3. Change to 3D View. To do so, click 3D. If you change from the 2D view to the 3D view, a snapshot of the live video image is shown as a fixed-image.

4. In the graphics toolbar, click . The dialog Connect Points appears.

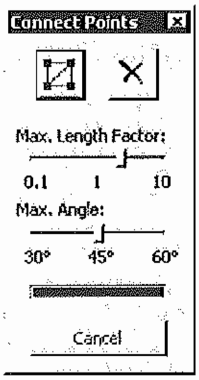


Figure 5.5: Dialog Connect Points

5. Select the maximum length factor (Max. Length Factor). By moving this slider with the mouse you can set the length of connection still allowed (minimum 1/10 to maximum factor 10). The factor refers to the median of the length of the visible connecting lines that already exist.

6. Select the maximum permissible angle of the viewer (Max. Angle). The software only generate areas the normal vector of which includes a maximum of this angle with the line of sight of the viewer (minimum 30° to maximum 60°).

7. If applicable, select the scan points you want to connect as described in SECTION 5.4.1.

8. In the dialog Connect Points click and the software will connect all or respectively the selected scan points so that triangles are generated. Existing connections are retained here.

☞ If connections already exist between the selected scan points, you will have to delete these first. Then you can connect the scan points automatically.

9. If necessary, rotate the object further and repeat step 8 and 9 until you have made all connections.

10. To delete connections, select the scan points as described in SECTION 5.4.1 and click ✕.

☞ If you change connections in combined files, then these changes are only saved in the combined file. The individual files remain unchanged. Read SECTION 8.5 on how to generate combined 3D files.

5.2.4 Deleting Connection

To delete connections, proceed as follows:

1. Change to 2D View.
2. Click ⧍.
3. Point at a connection. The cursor becomes a ⌖.
4. Select the connection. To do so, click it.
5. To select further connections, click them while holding the shift key pressed. You can also draw a rectangle with the mouse and use it to select connections which are partially or completely in the rectangle.
6. To remove a connection from the selection, click the connection while holding the shift key pressed.
7. To select all connections, press the key combination Ctrl+A or select Edit > Select All.
8. To delete the selected connections, press the Delete key or select Edit > Delete.

☞ To delete a triangle, you only have to delete one of the connections. The software automatically deletes the other connections.

5.2.5 Refining Scan Point Grid

If you have defined single scan points and connections in point mode, you can then refine the resulting grid. This means you increase the number of scan points in the grid and thus their density. Here, the software first of all calculates the distances between the selected scan points and sets an additional scan point in the middle on the connection. In the case of a quadratic polygon, an additional scan point is set in the middle.

To fine-tune the grid, proceed as follows:

1. Select several connected scan points as described in SECTION 5.4.1.
2. Click ⁙ or select Scan > Refine Grid. The software automatically inserts one more scan point respectively between the selected scan points.

5.2.6 Coarsing Scan Point Grid

If you have defined single scan points and connections in point mode, you can then coarsen the resulting grid. This means you decrease the number of scan points in the grid and thus their density. Here, the software first of all searches pairs of scan points which are connected and close together. You can select whether the points will be deleted or disabled for the scan.

☞ If you Delete Points, you can repeat the steps until you reach your target or no connected scan points are existing.
If you Disable Points, and carry out a scan for the remaining scan points, then you can interpolate the data of the disabled points from the data of the neighbors. To do so, activate Interpolate Disabled Points in presentation mode.

To coarsen the grid, proceed as follows:

1. Select several connected scan points as described in SECTION 5.4.1. You can also select none of the scan points to coarsen the whole grid.

2. Click in the toolbar of the video window or select Scan > Coarsen Grid. The dialog Coarsen Grid appears.

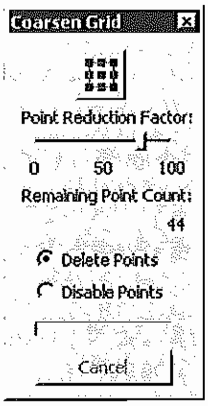


Figure 5.6: Dialog Coarsen Grid

3. Using the slider, select the Point Reduction Factor in percent. Below the Remaining Point Count will be shown.

4. Select Delete Points or Disable Points and click in the dialog. The software automatically deletes or disables the calculated number of scan points.

5.2.7 Merging Scan Points in the Grid

If you have defined single scan points and connections in point mode, you can merge neighboring scan points. This means you reduce the number of scan points in the grid and thus their density. To do this, the software first calculates the distances between the selected scan points. Then, starting from the minimum distance found, the software merges two points into one point if their distance is less than the minimum distance + 50%. The positions of the scan points on the video image and, if available, the 3D coordinates of the scan points are calculated by averaging the values of the two points that have been merged.

To merge scan points, proceed as follows:

1. Select several connected scan points as described in SECTION 5.4.1.
2. Click or select Scan > Merge Points. The software will merge neighboring scan points as described above.

5.2.8 Importing Scan Points

The icon and the command for geometry import are only available for the

- PSV with the option Data Import: Geometry,
- MSA with option Data import: Geometry (ImpGeo) or MSA-500 with option MSAGeo and option Data import: Geometry (ImpGeo), and
- PSV-3D.

☞ A prerequisite for importing scan points is a valid 3D alignment (refer to SECTION 4.5).

☞ If you are importing geometry from a file in Universal File format in which geometry components are defined (refer to SECTION 5.4.3), then these components are only incorporated for data set 82 (refer to table in SECTION 10.2.3).

To import scan points, proceed as follows:

1. Click [icon] or in the menu select Scan > Import Geometry. The dialog Open appears.

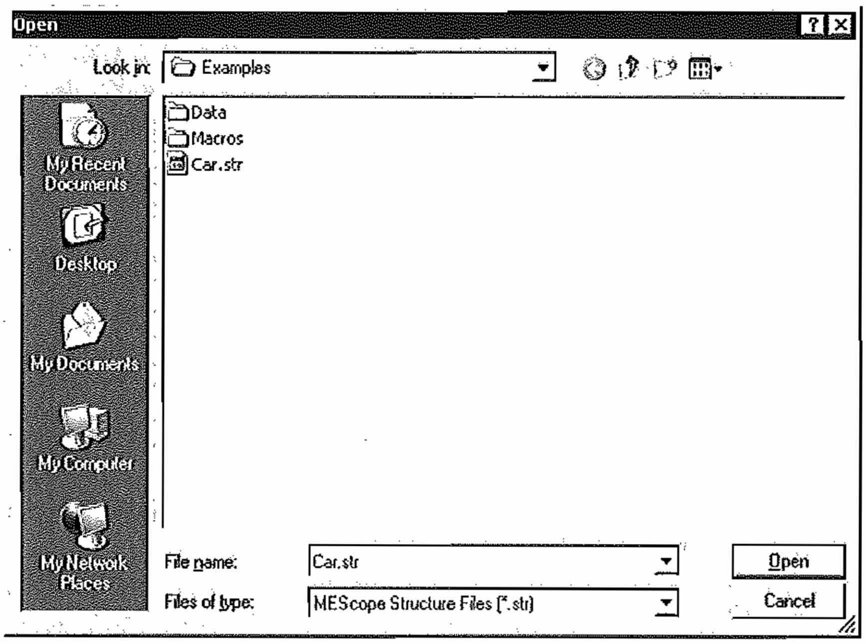


Figure 5.7: Dialog Open

2. Select the required file type.

☞ A simple ASCII format is supported for importing geometries. Here, only the point coordinates are imported, not the connections between the points.

3. Navigate to the saving location and select the required file.

4. Click Open. The scan points from the selected file are taken over in the video image. The indices of the scan points are also taken over.

☞ If you import geometries from ME'Scope5 (new file extension *.vtprj), then ME'Scope5 is automatically started, the appropriate file opened, and then the data is imported. If you have defined substructures in ME'Scope5, these are displayed as geometry components in the PSV software.

☞ If you are importing geometry from a file in ASCII format or a file in Universal File format which does not contain data set 164 with the units of the coordinates, then in the dialog Scaling of Imported Coordinates you have to enter a scaling factor (refer to FIGURE 5.8). The factor 1 stands for the unit 1 m, the factor 0.01 for the unit 1 cm etc.

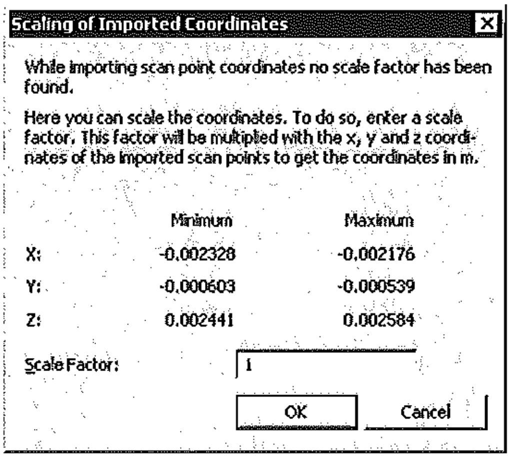


Figure 5.8: Dialog Scaling of Imported Coordinates

☞ If the object is deep, the imported points are not precisely on the object in the on-screen display. However despite this, during scanning, the laser beams hit the scan points precisely. If you want to correct the display on the screen, you can move the single points in the video image to the right position. This, however, does not have any effect on the measurement results.

Import scan points with Auto Align

For the geometry import you can have the position of the scan points on the video image modified. To do so, click the video image with the right mouse button and select Auto Align in the context menu. Then import the scan points as described above.

☞ This function is not available for the MSA/MSV.

As soon as the import is finished, a message window is displayed with the query as to whether the scan points in the video image are to be repositioned. Click Yes. The software moves the laser beam of the scanning head (for PSV-3D the scanning head Top) to the points, determines the position of the laser beam on the screen and positions the scan point exactly at this point.

☞ This process can take quite a while!

Work with large geometries

If the imported geometry is larger than the image section of the object in the video window, the video window is reduced correspondingly and the geometry is shown completely in both the 2D view as well as the 3D view.

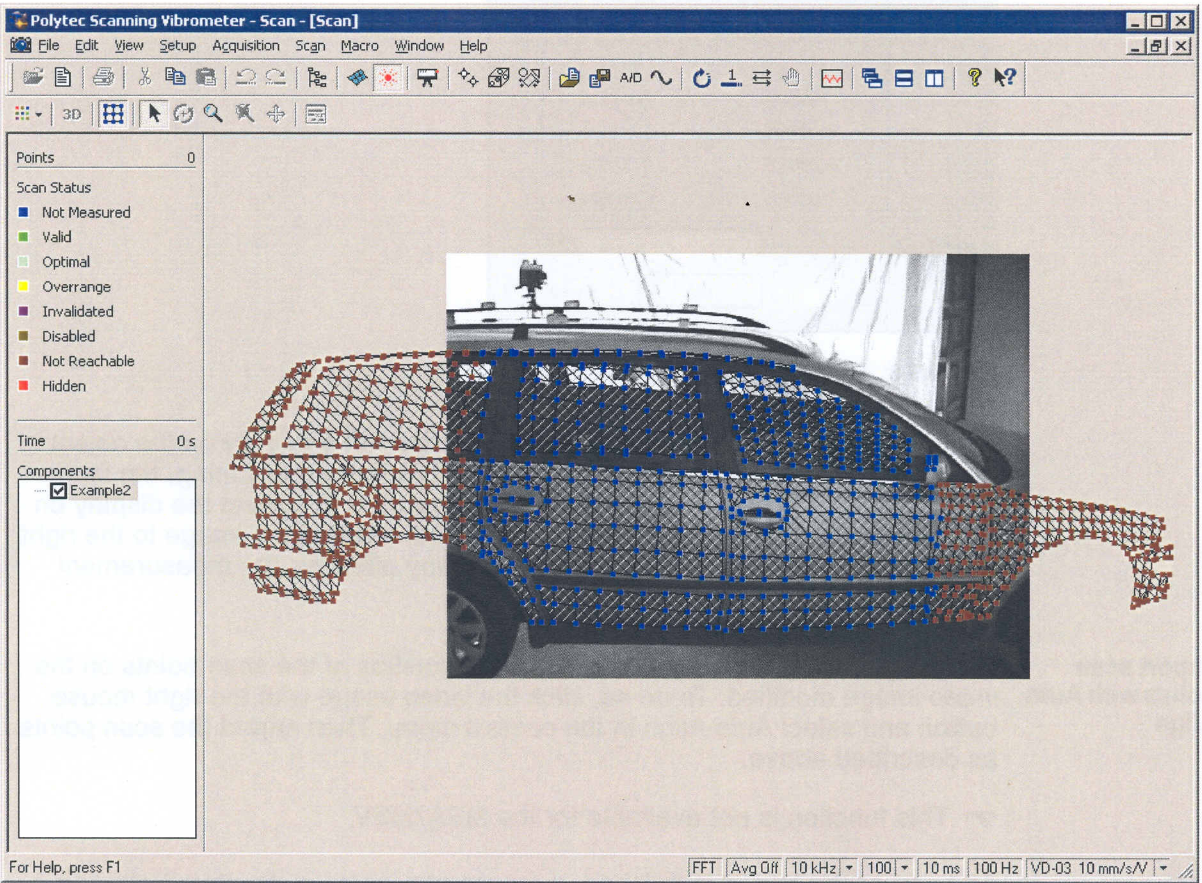


Figure 5.9: Example of geometry which is large

Generally several scan points will then be given the status Not Reachable or Hidden (refer to SECTION 7.3). Points that are Not Reachable will not be measured in a scan, Hidden points can be measured after a warning message.

To acquire the entire geometry of the object, proceed as follows:

1. Select the scan points which are not to be measured with the current measurement setup. See SECTION 5.4.1 on this.
2. Assign the status Disabled to these scan points. See SECTION 5.4.2 on this.
3. Start a scan as described in SECTION 7.2.
4. Change the position of the measurement setup so that you can scan another part of the object. To do so, perform a new 3D alignment as described in SECTION 4.5 and disable the scan points which are not to be measured.
5. Start another scan.

6. Repeat the steps 4 and 5 until you have acquired the whole geometry.

☞ If you are using 3D geometries, you can then merge the individual measurements to a combined file as described in SECTION 8.5.

5.2.9 Teaching-in Scan Points with the Geometry Scan Unit (only PSV and PSV-3D)

If the object you are making measurements on does not have a continuous surface on which you can define a grid of scan points (e.g. a sheet of glass which has only been covered with reflective film in certain places), you can define individual scan points with the aid of the optional geometry scan unit.

PSV and PSV-3D (1D)

1. Only PSV-3D: Select the scanning head Top.
2. Position the laser beam at the point at which you want to define a scan point.

☞ You can also use the hand set PSV-Z-051 on this or the optional PDA. Position the laser beam with the arrow keys on the hand set. Once the laser beam has reached the correct position on the object, press the button TEACH on the hand set. See your hardware manual on this as well.
You can read SECTION 5.2.2 to find out how to define scan points with the PDA.

3. Click . If the geometry laser is not active yet, the software will now switch over to it. The software makes a distance measurement. At the same time, both the coordinates of the point on the object and the position of the point on the video image are determined automatically.

☞ You can accelerate the speed at which new points are taught-in by switching over to the geometry laser first. To do so, click Scan > Geometry Laser. In this case the software does not keep on switching back and forwards between the vibrometer and the geometry laser for every single point.

Once you have taught-in all the scan points, you can link them together to become a surface as described in SECTION 5.2.3.

PSV-3D (3D)

If the positions of the scanning heads are known, you can acquire the geometry of the object by manually teaching-in the scan points.

1. Point all three laser beams at a point which you want to define as the scan point.

☞ The more precisely you define the scan points, the better the measurement result will be.
So please take your time defining the scan points!

2. Click ⁺⁺. This then automatically determines the coordinates of the point on the object and the position of the point on the video image. You can use the mouse to move this blue point. However this does not have any effect on the calculated 3D coordinates; it only affects the display in the video image.

☞ In the scanning head control, additional information is displayed in the element 3D Point. X, Y and Z describe the coordinates of the selected scan point. D shows the distance between the scan point and the front panel of the scanning head Top.

3. Once you have defined all scan points, you can connect them with each other. See SECTION 5.2.3 on this.

4. Click [icon] to finish scan point definition. You can now start scanning.

5.2.10 Defining Scan Points with Auto Align, only PSV-3D (3D)

You can also define single scan points with Auto Align. To do so, proceed as follows:

1. Click the video image with the right mouse button and select Auto Align in the context menu.

2. Hold the control key pressed and in the video image click the place on the object at which you want to define the scan point. Depending on the lighting conditions, the surface of the object etc., the software positions the three laser beams precisely at this point and defines a scan point.

Modify 3D coordinates

If the three laser beams jump to other positions after clicking ⁺⁺, then you have not performed the 2D alignment precisely enough. The 3D coordinates were only determined approximately via the video image. If the three laser beams do not meet at one point, then you could change the distance between the coordinates and the scanning heads. You can use this to minimize the distances of the laser spots. The minimal attainable distance is limited by the accuracy of the 3D alignment. To modify the coordinates, proceed as described in SECTION 5.4.2 under Modify 3D coordinates.

5.2.11 Editing Scan Points

If you have defined single scan points in point mode, you can select scan points and modify them.

Select scan points

You can select points as also described in SECTION 5.4.1 and modify the selected points as described in the following. To do so, click exactly the selected scan points with the right mouse button and select then the desired modification in the context menu.

☞ If you are clicking beside the selected scan points with the right mouse button, select Modify Selected Points and then the desired modification in the context menu.

Disable If the selected scan points are not to be measured, you can disable them. To do so, select Disable. The scan points are then disabled for measurements, geometry scans and for the function Assign Focus Best.

Enable To undo disabling, select Enable.

Modify 3D coordinates If 3D geometry data is available, you can modify the 3D coordinates of single scan points. See SECTION 5.4.2 under Modify 3D coordinates on this.

With the PSV you can then only modify the 3D coordinates of single scan points if there is 3D geometry, i.e. after importing geometry or after a geometry scan. See SECTION 5.2.8 or SECTION 5.5 on this.

Triangulate 3D coordinates (only PSV-3D) To triangulate the 3D coordinates of the selected scan points, select Triangulate 3D Coordinates. Using 2D and 3D alignment of all three scanning heads, the software calculates the 3D coordinates of the scan points. You will find more information on this in your theory manual.

Interpolate 3D coordinates If 3D geometry data is available for the selected scan points, you can interpolate the 3D coordinates of the selected scan points. To do so, select Interpolate 3D Coordinates. The software will then calculate the average distance of the neighboring points to the scanning head (Top with PSV-3D). The 3D coordinates are determined from this distance, taking into consideration the position of the selected scan points on the video image.

With the PSV you can then only interpolate the 3D coordinates of single scan points if there is 3D geometry, i.e. after importing geometry or after a geometry scan. See SECTION 5.2.8 or SECTION 5.5 on this.

Delete 3D coordinates To delete the 3D coordinates of the selected scan points, select Delete 3D Coordinates. Then the software deletes the 3D coordinates and uses the values of the 2D alignment to hit the scan points.

5.3 Common Functions in Both Modes

Several functions are available to you in both modes. They are described in the following sections.

- Showing and Hiding Scan Points, refer to SECTION 5.3.1
- Editing Figures, refer to SECTION 5.3.2

5.3.1 Showing and Hiding Scan Points

To show and hide the scan points in the live video image, in the toolbar of the application window, click or select Scan > Scan Points. You see the scan points as blue markers. You see the connections between the scan points as lines.

5.3.2 Editing Figures

Present figures Using the icons , , and , you can present figures in different ways. To do this, first select the figures as described below. Then click

:You can see the scan points and their connections.

: You can see the scan points, their connections and cross-hatching of the areas enclosed by the scan points. As a general rule, these areas are different from the geometric figures you have drawn.

☞ In presentation mode, areas which are enclosed by scan points are shown as enclosed areas.

: You see the connections between the scan points.

: You see cross-hatching of the areas enclosed by scan points.

Select figure To edit figures, you have to select them first. To do this, proceed as follows:

1. Click .
2. Point at a figure. At the right below the cursor, a cross appears.
3. Click. The software marks the edge of the figure with white markers.
4. To select further figures, click them while holding the control key pressed. The software marks every selected figure with white markers.
5. To select all figures, press the key combination Ctrl+A or select Edit > Select All.
6. To remove a figure from the selection, click the figure while holding the control key pressed. The white markers disappear.

Move figure

To move figures, select them as described above and then use the mouse to drag them in the direction required. You can also use the arrow keys.

Scan points which you have defined in point mode can be moved individually or in groups. You move single scan points, whether connected or freestanding, in exactly the same way as you move figures (see above). If you want to move several scan points at the same time, then you have to select them first. To do so, you have the following options:

- Hold the control key pressed and click the single scan points. Then release the control key.
- Mark the scan points you would like to move. To do so, use the mouse to draw a rectangle which encloses these scan points.

☞ If you want to add even more scan points to this selection, hold the shift key pressed and draw another rectangle.

Move the scan points with the mouse.

Scale figures

To scale figures, proceed as follows:

1. Select the figures as described above. If you want to scale scan points which you defined in point mode, then first of all select them as described above under Move figure. Then click  to group the selected scan points.
2. Point at one of the white markers which mark the edge of the figures. The cursor becomes a double arrow.

There are now following ways to scale:

3. Press the mouse button and drag in one of the directions the double arrow is pointing in. The anchor point is opposite the scan point you are dragging.

or

Press the control key and the mouse button and drag in one of the directions the double arrow is pointing in. The anchor point is the center of the figures.

or

Press the shift key and the mouse button and drag across to a corner point. The figures are resized in proportion horizontally and vertically.

Duplicate figure To duplicate figures, proceed as follows:

1. Select the figures as described above.
2. Click or select Edit > Copy. The figures are copied onto the clipboard.
3. Click or select Edit > Paste.

Delete figure To delete figures, proceed as follows:

1. Select the figures as described above.
2. Press the Delete key or select Edit > Delete.

Group figures To group figures, proceed as follows:

1. Select the figures as described above.
2. Click .
3. To undo grouping, click .

Arrange figures Using the four icons , , and , you can arrange figures behind each other (not in point mode). To do this, first of all, select one of the figures as described above. Then click

or : The figure moves into the foreground or background.

or : The figure moves one layer forwards or backwards.

Undo and redo You can undo up to 50 operations and then redo them. To do so, click and or select Edit > Undo and Edit > Redo.

5.4 Editing Scan Points (not APS)

You can also edit scan points if you have already finished scan point definition. To do so, you have the following options:

- Selecting Scan Points, refer to SECTION 5.4.1
- Modifying Scan Points, refer to SECTION 5.4.2
- Defining Geometry Components, refer to SECTION 5.4.3

5.4.1 Selecting Scan Points

Select scan points with the mouse

To select scan points with the mouse you have the following options:

- To select several scan points adjacent to each other, hold the shift key and the left mouse button pressed and draw one or more rectangles across the required scan points.
- To select several scan points that are not adjacent to each other, hold the control key pressed and click the required scan points.

Select all scan points

To select all scan points, press the key combination Ctrl+A or select Edit > Select All. You can also click the object with the right mouse button and select Select Points in the context menu. The dialog Select Scan Points appears.

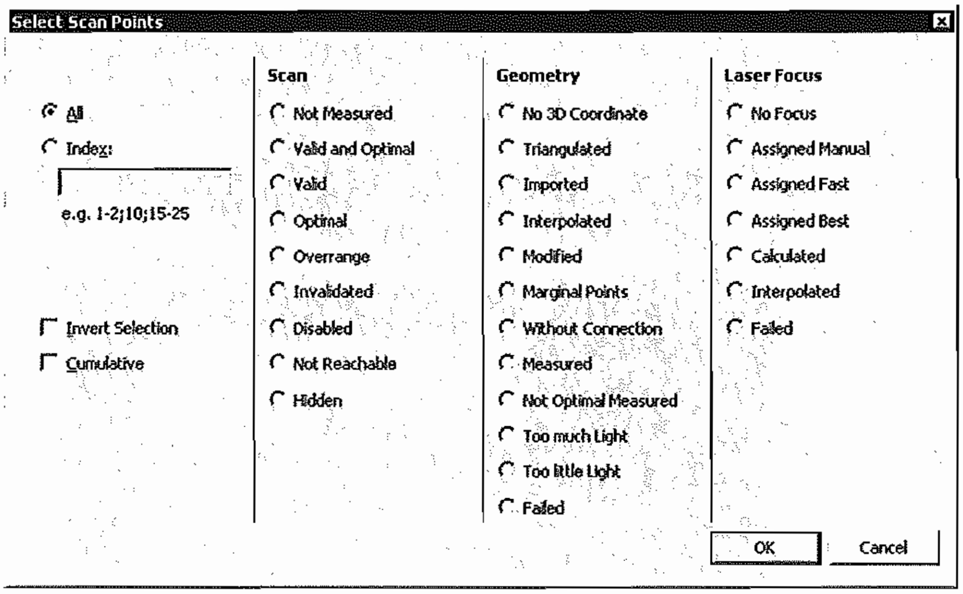


Figure 5.10: Dialog Select Scan Points

Select All and click OK.

Select scan points with certain properties

To select scan points which have certain properties, proceed as follows:

1. Select Edit > Select Points or click the object with the right mouse button and select Select Points in the context menu. The dialog Select Scan Points appears (refer to FIGURE 5.10).

☞ You can select the scan points according to general criteria (left) or according to the corresponding status (Scan Status, Geometry Status or resp. Laser Focus Status).

2. Here you select the criteria according to which you want to select the points and click OK.

☞ If you want to select the scan points on the basis of their index, you can display the indices. See SECTION 8.1.2 on this.

3. If you want to select points with different properties, then also tick the box Cumulative and repeat steps 1 and 2 as often as necessary.

4. To invert the selection, also tick the box Invert Selection.

5. To undo the selection, click again.

5.4.2 Modifying Scan Points

To retrospectively modify the selected scan points, select Edit > Modify Selected Points or click one of the selected scan points with the right mouse button and select the required command in the context menu.

☞ If you are clicking beside the selected scan points with the right mouse button, select Modify Selected Points and then the desired modification in the context menu.

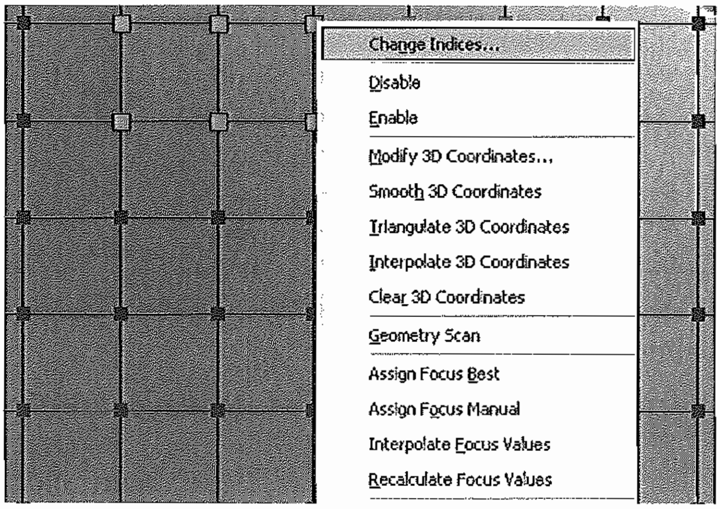


Figure 5.11: Command selection to modify scan points

You have the option of the following functions:

- Change indices
- Disable/Enable
- Modify 3D coordinates (only with 3D geometries)
- Smooth 3D coordinates (only with 3D geometries)
- Triangulate 3D coordinates (only for PSV-3D)
- Interpolate 3D coordinates (only with 3D geometries)
- Clear 3D coordinates (only with 3D geometries)
- Geometry scan
- Assign focus best (only with option APS Professional)
- Assign focus manual (only with option APS Professional)
- Interpolate focus values (only with option APS Professional)
- Clear focus values or recalculate them
- Select marginal points

Display indices You set up the display of scan point indices in the dialog Display Properties in the 3D View. To open the dialog, display the 3D View. To do so, click **3D** . Double-click the video image and display the page Data or click the video image with the right mouse button and select Data Properties in the context menu. You will also find a detailed description of the dialog in SECTION 8.1.

Change indices To change the indices of selected scan points, select Change Indices. The dialog Change Indices appears.

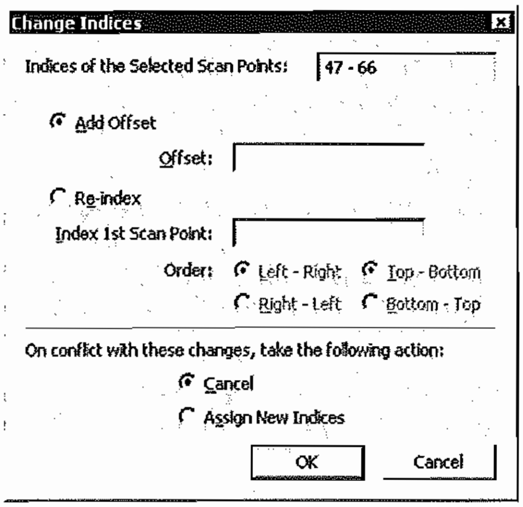


Figure 5.12: Dialog Change Indices

At the top you are shown the indices for selected scan points.

Add Offset: Click here if you want to add a certain amount to the indices of the selected scan points or want to subtract it from them. In the field Offset enter the required value. For a negative offset you have to enter an additional minus sign (–).

Example:
The selected scan points have the indices 1 - 21.
Offset: 10
The new indices will be 11 - 31.

Re-index: Click here if you want to renumber the selected scan points. In the field Index 1st Scan Point enter the value at which the new numbering is to start.

In addition to that, select the direction of the numbering, starting with the first scan point.

Example:
The selected scan points have the indices 27 - 52.
Index 1st Scan Point: 30
Direction: left - right, top - bottom
The new indices will be 30, 31, 32, ... They are assigned to the selected scan points from left to right and from top to bottom.

☞ The numbering of the indices only affects the display on the screen. It has no influence on the order in which the points are scanned.

On conflict with these changes, take the following action: Here you select how the software is to react if there is a conflict after changing the indices, i.e. numbers are assigned twice. If you select Assign New Indices, then the selected scan points are assigned the required indices. Indices for other scan points which already exist are then counted up, starting with the highest index +1.

Example:
You have defined 2500 scan points and want to newly assign the indices 1 - 200 to the scan points 200 - 400.
Index 1st Scan Point: 1
If there is conflict due to these changes, take the following action: Assign New Indices
The selected scan points are given the indices 1 - 200. The scan points which originally had the indices 1 - 200 will be given the indices 2501 - 2701.

☞ Independently of whether you abort assignment of new indices or carry it out anyway, you will see a message as to whether a conflict occurred.

Disable

If the selected scan points are not to be measured, you can disable them. To do so, select Disable. The scan points are then disabled for measurements, geometry scans and for the function Assign Focus Best.

Enable

To undo disabling, select Enable.

Modify 3D coordinates

You can modify the 3D coordinates of single scan points. To do so, for the selected scan point, select Modify 3D Coordinates. The dialog Modify 3D Coordinates appears.

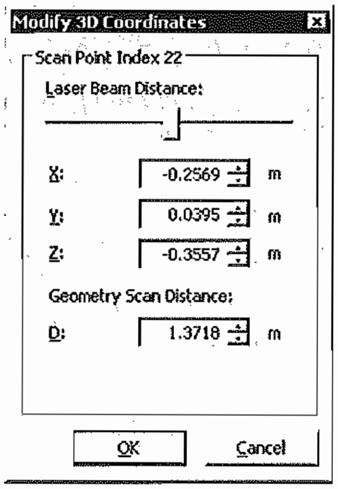


Figure 5.13: Dialog Modify 3D Coordinates

Here you can modify the values of the x-, y- and z-coordinates and also the distance determined by the geometry scan. If you move the laser beams with the aid of the slider Laser Beam Distance, the values in the fields are automatically updated. If however you modify the values in the fields, the slider remains in the set position.

You can also modify the 3D coordinates of several scan points at the same time. To do so, proceed as follows:

1. Select several scan points as described in SECTION 5.4.1.
2. Click one of the scan points with the right mouse button and select Modify 3D Coordinates in the context menu.
3. Modify the 3D coordinates as described above and click OK. The change to the 3D coordinates of that scan point is added to the 3D coordinates of all selected scan points. This allows you to move the position of several scan points in the same direction.

Video Triangulation (only PSV-3D)

You can also have the 3D coordinates for scan points recalculated by video triangulation. To do so, you will need the optional digital video camera A-CAZ-1000 and the option Video Triangulation. Using video triangulation, the three laser beams are optimally aligned at the scan point and the 3D coordinates are recalculated. Successful video triangulation requires:

- A continuous object (video triangulation goes wrong at edges and steps)
- Scan point must be in the video image
- All three laser beams must be visible in the video image
- 2D and 3D alignment carried out successfully

☞ All scan points for which video triangulation was successful are given the geometry status Modified. All scan points for which video triangulation was not successful are not measured.

For video triangulation, proceed as follows:

1. Select a scan point or several scan points as described in SECTION 5.4.1.

☞ Even if you have selected several scan points, video triangulation is only carried out for the scan point which you click with the right mouse button.

2. Click one of the scan points with the right mouse button and select Modify 3D Coordinates in the context menu. The dialog Modify 3D Coordinates appears.

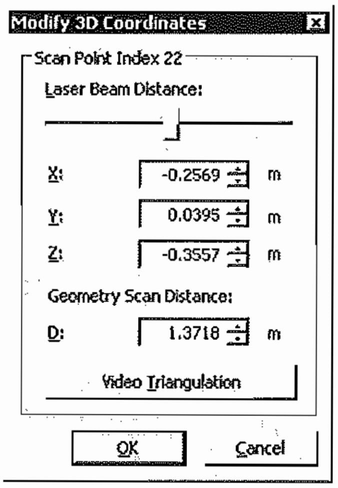


Figure 5.14: Dialog Modify 3D Coordinates with the option Video Triangulation

3. Then click Video Triangulation. The three laser beams are positioned optimally on the scan point with the aid of image processing and the 3D coordinates are modified. The 3D coordinates calculated this way are the coordinates at which the three laser beams comes closest to each other.

4. Click OK. The new 3D coordinates will be applied for the scan point. The change to the 3D coordinates of this one scan point is then transferred to the 3D coordinates of all selected scan points. This allows you to move the position of several scan points in the same direction.

☞ If video triangulation does not work, you will get an error message. You can now optimize the laser beams manually and then repeat video triangulation.

After video triangulation the laser beams are positioned at the newly calculated 3D coordinates. Only if there is an absolutely faultless 3D alignment, the three laser beams are optimally positioned with each other. As a general rule, the three laser beams are visible separately in the video image, in particular when you zoom right in.

☞ The position in the video image at which the three laser beams are superimposed on each other depends on the geometry status of the scan point. With the status Imported initially the position of each individual laser beam is ascertained in the video image and then the laser beams are positioned at the mean value of these positions. With all other statuses, the three laser beams are positioned at the position of the scan point in the video image.

Video Triangulation during Scan

You can also have video triangulation carried out automatically during the scan. To do so, select Scan > Video Triangulation during Scan and then:

- Standard (for every scan point and with correction of the 3D coordinates)
- Fast (not for every scan point and without correction of the 3D coordinates)
- Off (no video triangulation during scanning)

Select Standard and during the scan, the three laser beams will be optimally superimposed. If this function is active, the software carries out a video triangulation for every scan point before making the measurement and corrects the 3D coordinates of the respective scan point.

☞ If you have activated Video Triangulation during Scan, then you may not disable your PC while the measurement is running (Ctrl+Alt+Delete > Disable Computer). Video triangulation would otherwise malfunction, i.e. no measurement data would be captured.

Select Fast and the laser beams will only be optimally superimposed. No correction of the 3D coordinates will be effected. Furthermore, the fast video triangulation will not be carried out for all scan points. The correction values for the laser positions will be taken over from the neighboring scan points.

☞ A prerequisite for the fast video triangulation is that all scan points have the status Modified. We recommend, first of all carry out a standard video triangulation and then the fast video triangulation for further scans.

For scan points with the Geometry Status Imported the 2D coordinates are additionally recalculated. The 2D coordinates are updated once the scan is completed.

☞ If you want to carry out video triangulation for scan points with the Geometry Status Imported, we recommend doing this directly after import. You can then manually correct the scan points for which video triangulation failed and have them recalculated. Because the 3D coordinates have been modified, there is a change in the geometry status and thus also in the properties of Video Triangulation during Scan.

Smooth 3D coordinates

If 3D geometry data is available for the selected scan points, you can smooth the 3D coordinates of the selected scan points. To do so, select Smooth 3D Coordinates. The software will then calculate new 3D coordinates for each scan point taking the coordinates of the neighboring scan points into account. Thereby the weighting of the neighbors decreases with their spatial distance.

☞ Repeatedly executing the command makes the object smoother.

Triangulate 3D coordinates (only PSV-3D)

To triangulate the 3D coordinates of the selected scan points, select Triangulate 3D Coordinates. Using 2D and 3D alignment of all three scanning heads, the software calculates the 3D coordinates of the scan points. You will find more information on this in your theory manual.

☞ This triangulation depends on the quality of the 2D and 3D alignment. It only provides good results on level objects.

Interpolate 3D coordinates

If 3D geometry data is available for the selected scan points, you can interpolate the 3D coordinates of the selected scan points. To do so, select Interpolate 3D Coordinates. The software will then calculate the average distance of the neighboring points to the scanning head (Top with PSV-3D). The 3D coordinates are determined from this distance, taking into consideration the position of the selected scan points on the video image.

Clear 3D coordinates

To delete the 3D coordinates of the selected scan points, select Clear 3D Coordinates. Then the software clears the 3D coordinates and uses the values of the 2D alignment to hit the scan points.

Geometry scan

If you want to correct the 3D coordinates of the selected scan points, select Geometry Scan. The software will carry out a geometry scan as described in SECTION 5.5.

Assign focus best

Select Assign Focus Best to automatically focus the selected scan points respectively and to assign them a focus value. See also SECTION 5.6.2 on this.

☞ Automatic assignment of focus values is not used for the MSA as the focus values are already automatically assigned during the geometry scan.

Assign focus manual

Select Assign Focus Manual to manually assign a focus value to the respective scan points selected. See also SECTION 5.6.1 on this.

Interpolate focus values

To interpolate the focus values of the selected scan points, select Interpolate Focus Values. The focus values of the selected scan points are interpolated linearly from the focus values of the adjacent points.

Clear focus values

To clear the focus values of the selected scan points, select Clear Focus Values.

Recalculate focus values

If in the dialog Preferences on the page Geometry, you have marked the box Calculate Focus Values Automatically and for the selected scan points 3D coordinates are existent then you can recalculate the focus values of the scan points based on the focal length of the lens in the scanning head and their distance to the scanning head.

Select marginal points

To select the marginal points of the figure of the marked scan point, select Select Marginal Points.

5.4.3 Defining Geometry Components

In the video window of acquisition mode and in the presentation window in presentation mode, you can define geometry components and assign scan points to the individual components. The components are displayed in a list on the left in the video window or presentation window respectively. As default there is only one component initially, the Root Component.

☞ In acquisition and presentation mode, you can show and hide the scan points allocated to a component. This does not affect the average spectrum of the points.

Edit component To edit the root component or any other component, click the component with the right mouse button and select Edit in the context menu. The dialog Edit Component appears.

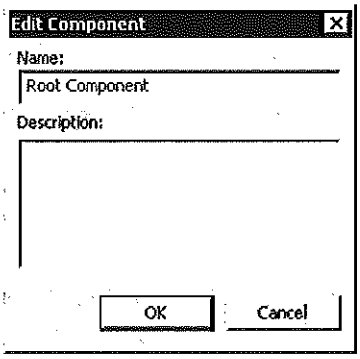


Figure 5.15: Dialog Edit Component

Name: Here you enter the desired name for the component.

Description: Here you can add a text to describe the components more precisely.

☞ If you only want to change the name of the component, click the component with the left mouse button and then press the key F2. Enter the new name.

Add component To add a component, with the right mouse button click the component below which you want to add a new component and select Add in the context menu. You can also click the components with the left mouse button and then press the Insert key. The software generates a New Component at the required position. You can edit this component as described above.

☞ You can create any structure for the components.

Remove component

To remove a component, click the required component with the right mouse button and select Remove in the context menu. You can also click the components with the left mouse button and then press the Delete key. If you press the key combination Shift+Delete, the selected component will be deleted without inquiry.

☞ Scan points that were assigned to deleted components are automatically assigned to the root component.

Assign scan points

To assign the individual geometry components scan points, proceed as follows:

1. Select the scan points you want to assign to a geometry component as described in SECTION 5.4.1.
2. Select the component which the scan points should belong to. To do so, click the component with the right mouse button and select Add Selected Points in the context menu.
3. Repeat these two steps until all scan points have been assigned to the required components.

☞ Scan points which you have not assigned to any other component are always automatically assigned to the root component.

Show and hide scan points

To show and hide the scan points of individual components, activate or deactivate the corresponding check box in front of the component name.

Select scan points of a component

To select the scan points of a component, click the component with the right mouse button and select Select Points in the context menu. You can also double-click the component.

☞ To select the scan points of several components, double-click the required components while pressing the control key.

Select all scan points of a component

To select all scan points of a component, i.e. the scan points of the secondary components as well, click the component with the right mouse button and select Select All Points in the context menu.

5.5 Carrying out a Geometry Scan (as an Option)

You can carry out a geometry scan with the following measurement systems:

- PSV or PSV-3D with Geometry Scan Unit, refer to SECTION 5.5.1
- MSA-500 with the Option MSAGeo, refer to SECTION 5.5.2

5.5.1 PSV or PSV-3D with Geometry Scan Unit

If you are using the scanning head PSV-I-400 with the optional geometry scan unit PSV-A-420, you can determine the distance between the scanning head and the object, even if you do not know the object geometry.

☞ If you are using the PSV-3D, then the geometry scan unit is on the scanning head Top.

You can use the geometry scan unit to assign 3D coordinates to scan points. To do so, first of all define the scan points as described in CHAPTER 5 and then determine the 3D coordinates of the scan points.

The geometry scan unit provides the scanning head with a second laser apart from the vibrometer laser to determine the object geometry. In contrast to the vibrometer laser, the geometry laser can not be focused. This means that in general it generates a larger spot of light than the vibrometer laser. To check whether the laser is also hitting the required points at the edges or periphery of the object under investigation, you can switch over to the geometry laser at any time. If the spot of light from the geometry laser only partially hits the object, it is not possible to make a distance measurement and you have to correct the laser position again. Apart from that, with the aid of the geometry laser you can check and see if your scanning head is still adjusted correctly. If both laser beams with the same setting do not hit the same point on the object, then the scanning head is probably misaligned.

Geometry laser To switch between the vibrometer laser and the geometry laser, select Scan > Geometry Laser.

Geometry point To make a distance measurement between the scanning head and the object, position the laser beam at any point on the object and select Scan > Geometry Point. The software will make a distance measurement to this point, will calculate the x-, y- and z-coordinates of this point from the results of this measurement and the current mirror angles and will display these coordinates.

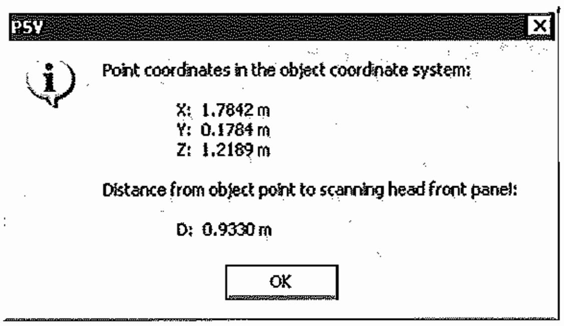


Figure 5.16: Display of the coordinates for the PSV or PSV-3D

If there is a valid 3D alignment, then the coordinates are given in the object coordinate system that you defined through the 3D alignment. Otherwise the coordinates are given in the scanning head system which you can define as described in SECTION 4.1.1 under Enter coordinates of axes.

Geometry scan

To scan an object, the 3D geometry of which is not yet known by the software, select Scan > Geometry Scan. If applicable, the software switches over to the geometry laser automatically. The geometry laser is positioned at every scan point, measures the distance from the scanning head and determines every x-, y- and z-coordinate as described above under Geometry point.

☞ You can also select individual scan points as described in SECTION 5.4.1 and only carry out a geometry scan for these scan points. To do so, click one of the selected scan points with the right mouse button and select Geometry Scan.

Once the software has determined the coordinates of the scan points, you can check the geometry by switching to the 3D view. You also can check individual coordinates of the scan points by selecting the corresponding scan point and reading the coordinates in the scanning head control. Afterwards you can start a scan. When you start, it automatically switches over to the vibrometer laser.

☞ A prerequisite for a geometry scan is a valid 3D alignment.

☞ If the geometry scan has not been carried out correctly or you have canceled it, you will get a status report (refer to FIGURE 5.17). You can decide whether to finally abort the geometry scan or whether to remeasure the remaining scan points or to have them interpolated. See SECTION 7.2 or SECTION 9.1 and your theory manual on this. Independently of whether you have carried out the geometry scan or have aborted it, you can subsequently check the status of the scan points and if necessary take further measures. See SECTION 5.4.1 and SECTION 7.3 on this.

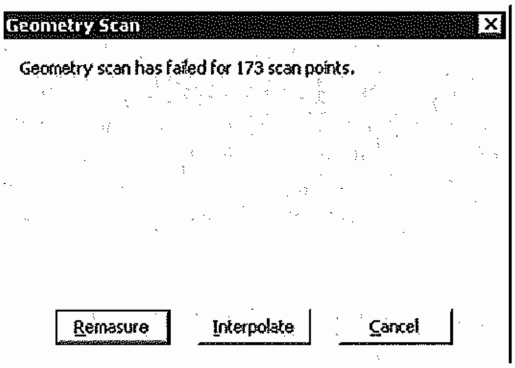


Figure 5.17: Status report if geometry scan is incomplete

The 3D coordinates of the geometry points are determined in the coordinate system of the alignment points (object system). The coordinates are displayed in the element 3D Point.

Filter

The geometry scan unit is equipped with a filter which you can use to weaken the intensity of the laser beam.

Usually you initially make a distance measurement (Geometry Point) without this filter. If the scanning head is receiving too much light, you will be advised to use the filter. In this case switch the filter on. If you are using a geometry scan unit without a toggle switch, the filter is switched on or off in the software. To do so, click the box Filter in the scanning head control. If you are using a geometry scan unit with a toggle switch FILTER, the filter is switched on or off on the geometry scan unit. See your hardware manual on this.

If you are using a geometry scan unit without a toggle switch, then initially the scan is carried out without this filter for a geometry scan. If the scanning head receives too much light at some scan points, these scan points are automatically remeasured with the filter switched on.

Transform 2D geometry to 3D geometry

You can transform the 2D geometry of a three-dimensional object into 3D geometry. Prerequisite is that you have previously performed a 3D alignment. To transform 2D geometry into 3D geometry, then start a geometry scan. This makes the three-dimensional geometry of the object known to the software.

5.5.2 MSA-500 with the Option MSAGeo

If you are using the junction box MSA-E-500 with the scanning head MSA-I-500, you can then also determine the position of the focus point on the z-axis even if you do not know the geometry of the object.

You can use the option MSAGeo to assign 3D coordinates to scan points. To do so, first of all define the scan points as described in CHAPTER 5 and then determine the 3D coordinates of the scan points.

Geometry point

To make a geometry point measurement, position the laser beam at any point on the object and select Scan > Geometry Point. From the results of this measurement, and the position of the z-axis in the measurement microscope, the software will calculate the x-, y- and z-coordinates of this point and will display these coordinates.

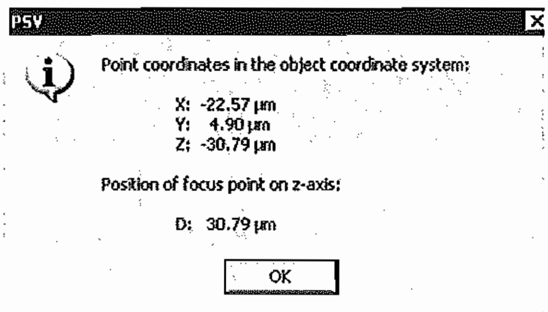


Figure 5.18: Display of coordinates for the MSA

If there is a valid 3D alignment, then the coordinates are given in the object coordinate system that you defined through the 3D alignment. Otherwise the coordinates are given in the scanning head system which you can define as described in SECTION 4.5.7.

Geometry scan To scan an object, the 3D geometry of which is not yet known by the software, select Scan > Geometry Scan. The software focuses the laser beam on every scan point, determines the position of the z-axis in the measurement microscope and thus every x-, y- and z-coordinate as described above under Geometry point.

☞ You can also select individual scan points as described in SECTION 5.4.1 and only carry out a geometry scan for these scan points. To do so, click one of the selected scan points with the right mouse button and select Geometry Scan.

If the software has determined the coordinates of all scan points, you can check the geometry by switching to the 3D View. You also can check individual coordinates of the scan points by selecting the corresponding scan point and reading the coordinates in the scanning head control. Afterwards you can start a scan.

☞ A prerequisite for a geometry scan is a valid 3D alignment.

☞ If the geometry scan has not been carried out correctly or you have canceled it, you will get a status report (refer to FIGURE 5.17). You can decide whether to finally abort the geometry scan or whether to remeasure the remaining scan points or to have them interpolated. See SECTION 7.2 or SECTION 9.1 and your theory manual on this. Independently of whether you have carried out the geometry scan or have aborted it, you can subsequently check the status of the scan points and if necessary take further measures. See SECTION 5.4.1 and SECTION 7.3 on this.

The 3D coordinates of the geometry points are determined in the coordinate system of the alignment points (object system). The coordinates are displayed in the element 3D Point.

Transform 2D geometry to 3D geometry You can transform the 2D geometry of a three-dimensional object into 3D geometry. Prerequisite is that you have previously performed a 3D alignment. To transform 2D geometry into 3D geometry, then start a geometry scan. This makes the three-dimensional geometry of the object known to the software.

5.6 Teaching-in Focus Values (as an Option)

You have the option of assigning focus values to the scan points. This makes it easier to focus if several objects are to be scanned which are at different distances from the scanning head, or if the object has three-dimensional geometry. A focus value is determined when focusing automatically. You have the option of saving the focus values determined in this way with the object geometry. They can then be used for any number of measurements, providing the object geometry remains the same. Teaching-in the focus values is only available if you have the option APS Professional.

There are different ways of assigning focus values to the scan points:

- Assigning Focus Values Manually, refer to SECTION 5.6.1 (single scan points)
- Assigning Focus Values Automatically, refer to SECTION 5.6.2 (all scan points, fast or optimal or calculate automatically)

5.6.1 Assigning Focus Values Manually

You can manually assign focus values to single scan points. This is particularly useful if the object under investigation is made up of one or more planes which are equidistant from the scanning head, i.e. the object is not at an angle to the scanning head.

Assign a focus value

To assign a focus value manually, proceed as follows:

1. Use the middle mouse button to position the laser beam at the point at which you want to determine the focus value and then click .

☞ If you have assigned a special function to the middle mouse button (e.g. double-click), position the laser beam using the icons Position in the scanning head control.

2. Select the scan points which you want to assign a focus value to as described in SECTION 5.4.1.

3. Click one of the scan points with the right mouse button and select Assign Focus Manual in the context menu. The focus value determined previously is assigned to all selected scan points.

☞ If you click next to the selected scan points with the right mouse button, you select Modify Selected Points and then Assign Focus Manual in the context menu.

4. You can now check the focus settings as described in SECTION 5.6.3.

5. Then you can start a scan.

☞ If you have not assigned focus values to all scan points, when the scan starts you will be given the message that not all scan points have a valid focus value. You can repeat Assign Focus Manual or start the scan anyway.

Reset focus value

To reset a manually assigned focus value, click the scan point with the right mouse button and select Clear Focus Values in the context menu.

Interpolate focus values

To interpolate the focus values of the selected scan points, select Interpolate Focus Values. The focus values of the selected scan points are interpolated linearly from the focus values of the adjacent points.

5.6.2 Assigning Focus Values Automatically

☞ Automatic assignment of focus values is not used for the MSA as the focus values are already automatically assigned during the geometry scan.

Calculate automatically

If, for the scan points 3D coordinates are existent, you can automatically calculate all focus values of the scan points based on the focal length of the lens in the scanning head and their distance to the scanning head. To do so, mark the respective box in the dialog Preferences on the page Geometry (refer to SECTION 3.4). If you do not know the focal length of the lens, then you will have to calculate it. To do so, start a scan with the function Assign Focus Fast or Assign Focus Best. Every scan point is assigned a focus value. Then click Calculate. The focal length of the lens is entered and used for calculating the focus values.

Assign Focus Fast

Select Scan > Assign Focus Fast to assign a focus value to all scan points quickly. Scan points at different distances from the scanning head are approached using one scanning head (PSV) or all three scanning heads (PSV-3D) and are automatically focused. For the PSV, you have to enter the correct coordinates for the distance in the element 2D Point in the scanning head control before you use Assign Focus Fast (refer also to SECTION 4.1).

☞ This method is only suitable for level surfaces which are positioned at right angles to the laser beam.

In contrast, for the PSV-3D and for 3D geometries in the PSV which have been imported or determined by a geometry scan, the precise position of the scan points is used. The focus values for all other scan points are then calculated by the software.

Assign Focus Best

Select Scan > Assign Focus Best to automatically focus all scan points respectively and to assign them a focus value. This can take up to 10 seconds per scan point. For the PSV-3D focusing is done with all three scanning heads at the same time.

☞ If you abort Assign Focus Best, the focus values determined until then are saved and used for the subsequent scan. For all scan points which have not had a focus value determined, the focus value last set is used for a scan. The function Focusing during Scan is not activated.

Assign focus values

To automatically assign focus values to all scan points, proceed as follows:

1. Select Scan > Assign Focus Fast or Scan > Assign Focus Best. The scan points are focused automatically as described above and the focus values are saved with the object geometry.
2. In the menu Scan, Focusing during Scan is activated by the software. This has the effect that during a scan, the focus values are set for every scan point using the optics.
3. You can now check the focus settings as described in SECTION 5.6.3.
4. Then you can start a scan.

☞ If you have canceled Assign Focus Best, when the scan starts, you will be given the message that not all scan points have a valid focus value. You can repeat Assign Focus Best or start the scan anyway.

5.6.3 Checking the Focus Settings

If you click a scan point and leave the mouse cursor there, then the focus values of this scan point are displayed on a yellow background next to the cursor. The current focus value is shown as a percentage and as an absolute value. The value 0% (0) means that the optics in the scanning head have been moved right to the end in the direction close-up (N). The value 100% (3300) means that the optics in the scanning head have been moved right to the end in the direction infinity (F).

At the same time the optics are set to the focus value of this scan point.

If the focus values are not to be taken into consideration during scanning, select Scan > Focusing during Scan to deactivate focusing during a scan.

6 Parameters for Data Acquisition

There are several ways for you to set the parameters for data acquisition. See SECTION 6.1 on this.

You will find a description of all parameters in SECTION 6.2.

6.1 Setting the Parameters

To set the parameters for data acquisition, you have the following options:

- In the status bar
- In the dialog Acquisition Settings
- By loading the settings from a file

Status bar

You can set some parameters on the right in the status bar. The parameters which are shown there depend on the measurement mode set. To see which parameters they are, point at a setting and leave the cursor there for a moment. The parameter is then shown on a yellow background next to the cursor and also on the left in the status bar. To set a parameter, click the arrow on the right of it and select the required setting in the context menu.

Dialog

You can set all parameters in the dialog Acquisition Settings. To do this, proceed as follows:

1. Click A/D or select Acquisition > Settings. The dialog appears. It consists of several pages each with a group of parameters respectively. To display a certain page, click the name of the group.
2. Display the page General and set the parameters. You will find information on this in SECTION 6.2.1. The pages in the dialog can change with the measurement mode selected.
3. Set the parameters on all other pages of the dialog. You will find information on this in SECTION 6.2.
4. When you have set all parameters, click OK.

File

You can load settings from setting files and measurements. See SECTION 10.1.4 on this. You can save the current settings as described in SECTION 10.2.7.

6.2 Description of the Parameters

The individual measurement parameters are described in detail in the following sections:

- Measurement mode and averaging on the page General, refer to SECTION 6.2.1
- Channel allocation on the page Channels, refer to SECTION 6.2.2
- Filter settings on the page Filter, refer to SECTION 6.2.3
- Frequency settings in measurement mode FFT on the page Frequency, refer to SECTION 6.2.4
- Windowing of the input signals on the page Window, refer to SECTION 6.2.5
- Trigger settings on the page Trigger, refer to SECTION 6.2.6
- Signal Enhancement and Speckle Tracking on the page SE, refer to SECTION 6.2.7
- Vibrometer settings on the page Vibrometer, refer to SECTION 6.2.8
- Generator settings on the page Generator (as an option), refer to SECTION 6.2.9
- Frequency settings in measurement mode Zoom-FFT (as an option) on the page Frequency, refer to SECTION 6.2.10
- Settings to the measurement mode FastScan (as an option), refer to SECTION 6.2.11
- Settings to the measurement mode Time (as an option), refer to SECTION 6.2.12
- Settings to the measurement mode MultiFrame (as an option), refer to SECTION 6.2.13
- Frequency settings in measurement mode MultiFrame (as an option) on the page Frequency, refer to SECTION 6.2.14

6.2.1 General

On the page General, you set the measurement mode, averaging and automatic remeasuring.

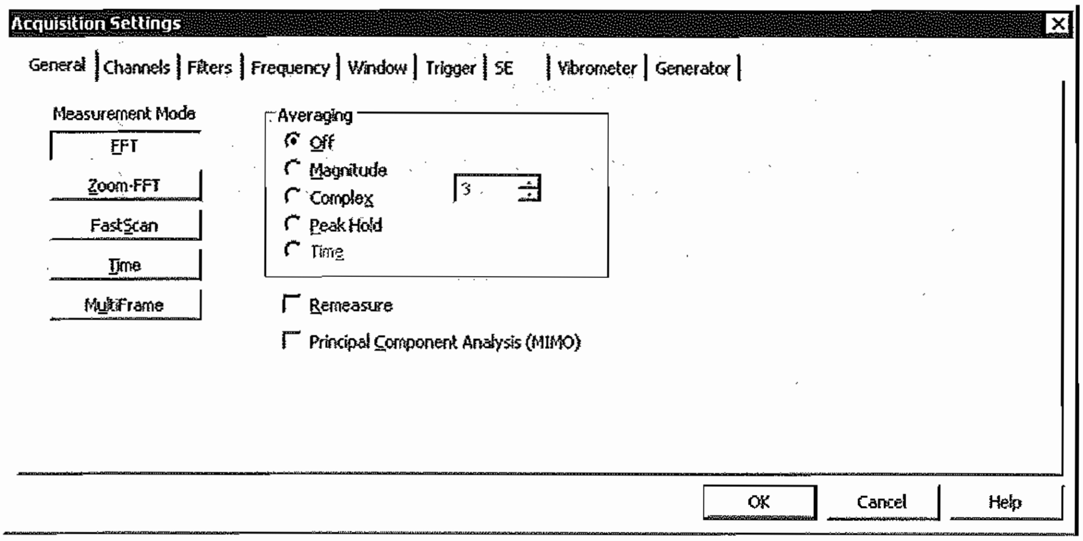


Figure 6.1: Page General

Measurement Mode

On the left you select the measurement mode. The measurement mode FFT is available as standard, all others are optional. The pages in the dialog can change with the measurement mode selected. If, for example, you select the measurement mode FastScan, then a page appears with parameters for FastScan. Other pages disappear.

Averaging

On the right you set the averaging. In measurement mode I/Q (only with option VDD) you can not average. By averaging you can improve the signal-to-noise ratio of spectra. You will find detailed information on averaging in your theory manual.

Off: You do not average.

Magnitude: Select magnitude averaging if you

- are neither using a reference signal nor a trigger

or

- are using stochastic excitation – for example, in a wind tunnel.

Complex: Select complex averaging if you

- are using a reference signal or a trigger

and

- are using deterministic excitation.

On the right you enter the number of averages. The time needed for a measurement will increase by this factor.

Peak Hold: Select Peak Hold for averaging if you want to calculate and display the respective maximum of the spectra over the set number of averages.

☞ Peak Hold is not available in the measurement mode Time.
If you select Peak Hold averaging, you can not make any further quality adjustment for Signal Enhancement (Fast ... Best, refer to SECTION 6.2.7).

You will find more information on the measurement mode Peak Hold in your theory manual.

Time: In measurement mode Time you can only select Time averaging. A prerequisite for this is that you trigger the measurements.

☞ Please note that spectra and time signals with the Scan Status Overrange are not taken into account when averaging. But if all spectra previously acquired have the status Overrange, then first of all these spectra will be averaged and displayed. Only when the first spectrum will be captured without Overrange, the average counter is reset and the previously measured spectra with the status Overrange are rejected. Any other spectra with the status Overrange are then also rejected.

Remeasure

At the bottom you can activate automatic remeasuring. After a scan all the scan points with the status Overrange, Invalidated and Not Measured are then remeasured at a slightly different position. If Signal Enhancement is active for at least one channel (refer to SECTION 6.2.7), then in the measurement modes FFT, Zoom-FFT and MultiFrame scan points with the status Valid are also remeasured.

☞ You can also start remeasuring manually. See SECTION 7.2 on this. After changing from acquisition to presentation mode you can also identify single scan points to be remeasured. See SECTION 9.1 on this.

Principal Component Analysis (MIMO)

With the option PCA (Principal Component Analysis) you can make a MIMO data acquisition. To do so, mark the box Principal Component Analysis (MIMO) in the lower part of the dialog.

☞ So that you can start MIMO data acquisition, you have to have selected Magnitude or Complex as averaging. On the page Channels specify at least two reference channels and on the page Generator tick the box Multiple Channel (MIMO) (refer also to SECTION 6.2.2 and SECTION 6.2.9).

You will find more information on MIMO data acquisition in your theory manual.

6.2.2 Channels

On the page Channels you activate the required measurement channels and set their parameters for digital data acquisition. For certain hardware configurations and measurement modes, parameters on the page are not available or are set permanently.

Work in the table

To accelerate adjustment of the settings, you can use the icons (Copy) and (Insert) above the table. To do so, tick the required cell(s), line(s) or column(s) as described in the following. Then click , mark the cell(s), line(s) or column(s) which you want to transfer the settings to and click .

Or:

Click with the right mouse button and select Copy or Insert in the context menu.

- To mark a cell, click it.
- To mark a line, click the first cell of this line.
- To mark a column, click the head of this column.
- To mark several consecutive cells, lines or columns, hold the shift key pressed and mark the first and last cell/start of line/column head with the mouse.
- To mark several cells, lines or columns which are not consecutive, hold the control key pressed and mark the respective cells/starts of line/column heads with the mouse.
- If you want to mark the whole table, click the cell Channel.

In the same way you can copy settings into and out of other applications such as Microsoft® Excel.

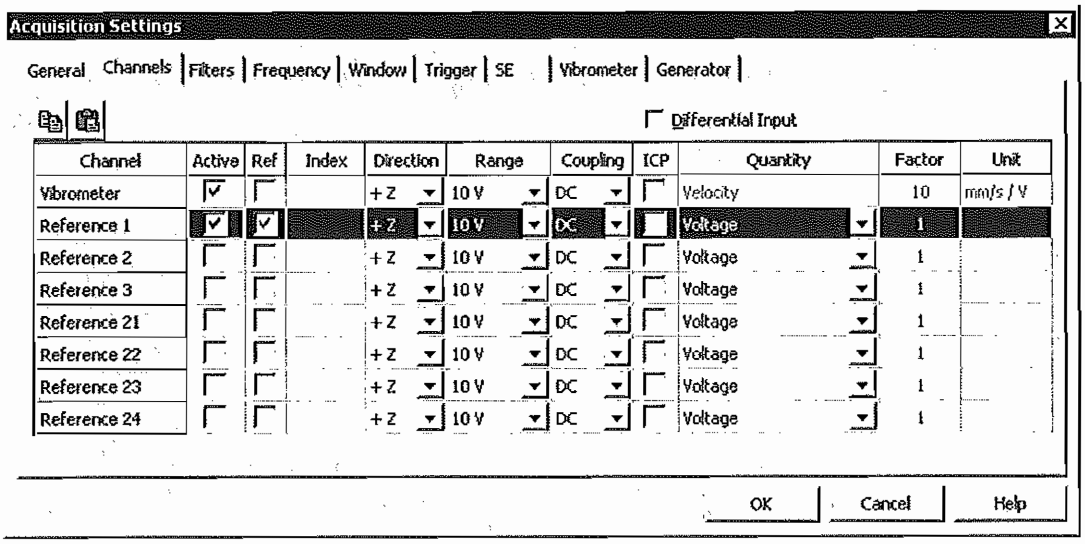


Figure 6.2: Page Channels

Channel: Here the channels are displayed that are available to you for your system.

☞ For the PSV-3D, the channels Vibrometer 3D and Reference 1 as well as Reference 21 to Reference 24 are available to you.
If you want to operate the PSV-3D as a pure PSV-1D (junction box PSV-E-40x-1D), then the allocation of the channels displayed does not match the names on the junction box. Pay attention to the following allocation: Vibrometer corresponds to VELO TOP, Reference 1 corresponds to VELO LEFT, Reference 2 corresponds to VELO RIGHT and Reference 3 corresponds to REF.

Active: Here you mark the channels you want to make measurements on.

Ref: This column only appears if there are more than two input channels available in the software. A channel is either an answer channel or a reference channel. The channel Vibrometer is always an answer channel.

For systems with two channels the channel Reference 1 is always a reference channel. For systems with more than two channels you can select which channel is the reference channel (apart from Vibrometer). To do so, mark it in the column Ref. If the column Ref is not marked for one channel, it is used as the answer channel, even if it is called Reference.

The first reference channel is given special treatment. It serves as a phase reference for the other channels if you

- average magnitudes (refer to SECTION 6.2.1) or
- do not use a trigger (refer to SECTION 6.2.6).

When calculating the frequency response function, all possible combinations of type answer channel/reference channel are formed.

Example:

Vibrometer & Reference 1: answer channels
Reference 2 & Reference 3: reference channels

The following signals are available as frequency response function:

Vibrometer/Reference 2
Vibrometer/Reference 3
Reference 1/Reference 2
Reference 1/Reference 3

When using more than one reference channel, frequencies are respectively formed as a total answer signal/reference signal. This is correct with an excitation signal and several reference signals (e.g. self-excited system, vibrometer and microphone as reference).

☞ When using the measured frequency responses for Experimental Modal Analysis, please note that these can not easily be fed in to a multi-reference procedure in the modal analysis software package. To do this, it is also necessary to determine the transmission function. For these calculations the total answer signal of every individual sample point must be divided up into the individual references (Principal Component Analysis, only with option PCA). This is only possible if the reference signals are uncorrelated (refer also to SECTION 6.2.9). If you are running a principal component analysis, you have to select at least two reference channels. You will find detailed information on this in your theory manual.

Index: Here you enter the index of the scan point at which you are measuring the reference. You can read this index under 2D Point or 3D Point in the scanning head control if you click the scan point with the mouse. Then click the pertinent line in the column Index and enter the displayed value there.

☞ The default setting in the column Index is 0. However a reference point index of 0 is ignored when calculating the reference. In principle the number of scan points is the highest possible value which you can enter in the field Index. However, the software allows you to enter higher values so that you can make several measurements with the same index and then can reunite them in an external program.

Direction: Here you can enter the direction of the vibration. The default setting is +Z. However you can also select another direction (±X/Y/Z) for all channels apart from Vibrometer 3D. With the direction of the vibrometer channel you set the orientation of the scanning head system. See SECTION 4.5.3 and your theory manual on this.

☞ In the presentation window you can also retrospectively change the vibrational direction, see SECTION 9.1 on this.

☞ The values from the columns Index and Direction are used when exporting in UFF and ME'Scope. You can change the settings for export again (refer to SECTION 10.2.3 and SECTION 10.2.4).

Range: Here you select the input range of the data acquisition board for every channel.

Coupling: Here you select the input coupling for every channel.For vibrometer channels you have to set DC coupling, for other sensors DC coupling is recommended. Only PSV-200-1: For certain hardware configurations, select the input coupling via the cabling of the data acquisition board. See your PSV-200 hardware manual on this.

Impedance: This column is only shown if the Spectrum data acquisition board MI.3025 or resp. M2i.3027, or an oscilloscope with the UHF is installed. In this case you can set the input resistance of the board or resp. oscilloscope here (50 Ω or 1 MΩ).

☞ You can not change the input resistance if the software has it automatically detected and adjusted.

ICP: If you are using one of the junction boxes VIB-Z-012, VIB-Z-016, PSV-E-40x or PSV-E-40x-3D and in the list Junction Box on the page Devices you have set it accordingly, you can switch ICP® on and off for the channel REF or REF 1 and if applicable, for REF 2, REF 3 and REF 21 to REF 24.

☞ If you are using such a junction box and have activated ICP®, then we recommend to use DC coupling as for frequency response measurements you should select the same coupling for all channels. While doing so, pay attention that with ICP® being activated a high pass filter with an extreme low cutoff frequency (0.02 Hz) is automatically switched on. The settling time of the high pass filter can take several minutes meanwhile exceeding the measurement range is indicated.

Quantity: Here you select the physical quantity which you want to measure on the respective channel.

☞ Using a digital filter, the software can integrate or differentiate the time signal of some measured quantities. See SECTION 6.2.3 on this.
If the quantity Displacement, Velocity or Acceleration is selected, then the spectra of both the others are calculated by integration or differentiation. This is also applicable for the quantities Angle, Angular Velocity and Angular Acceleration as well as Volume, Volume Velocity and Volume Acceleration.

Factor: Here you enter the calibration factor for every channel, i.e. the measurement value which corresponds to an analog input signal of one volt. If a vibrometer is connected up (refer to SECTION 3.2), the software will enter the calibration factor for this channel corresponding to the measurement range set on the page Vibrometer (refer to SECTION 6.2.8).

☞ You can also enter negative calibration factors here if you have not selected Voltage as the physical Quantity.

Unit: Here, the software enters the SI unit of the set quantity.

Differential Input: If you are using one of the junction boxes VIB-Z-012, VIB-Z-016, PSV-E-40x or PSV-E-40x-3D, then here you can activate the differential input for all selected channels. You can thus avoid ground loops and generally improve reliability. All activated channels are switched to ungrounded by the differential input so that distortions through harmonics of the mains frequency (humming) can no longer appear in the spectrum.

6.2.3 Filters

On the page Filters you set the digital filters for the input signals

- to limit the bandwidth

and

- for differentiation or integration.

The page Filters is divided into two parts. In the first part you select the filter type to limit the bandwidth – high pass, low pass etc. – and select the integration or differentiation filter. In the second part you set the filter parameters to limit the bandwidth, i.e. cutoff frequency and quality. You can also see the frequency response there.

Work in the table

To accelerate adjustment of the settings, you can use the icons (Copy) and (Insert) above the table. To do so, tick the required cell(s), line(s) or column(s) as described in the following. Then click , mark the cell(s), line(s) or column(s) which you want to transfer the settings to and click .

Or:

Click with the right mouse button and select Copy or Insert in the context menu.

- To mark a cell, click it.
- To mark a line, click the first cell of this line.
- To mark a column, click the head of this column.
- To mark several consecutive cells, lines or columns, hold the shift key pressed and mark the first and last cell/start of line/column head with the mouse.
- To mark several cells, lines or columns which are not consecutive, hold the control key pressed and mark the respective cells/starts of line/column heads with the mouse.
- If you want to mark the whole table, click the cell Channel.

In the same way you can copy settings to and from Microsoft® Excel.

Select In the first part of the page Filters you select the filter types you want for each channel.

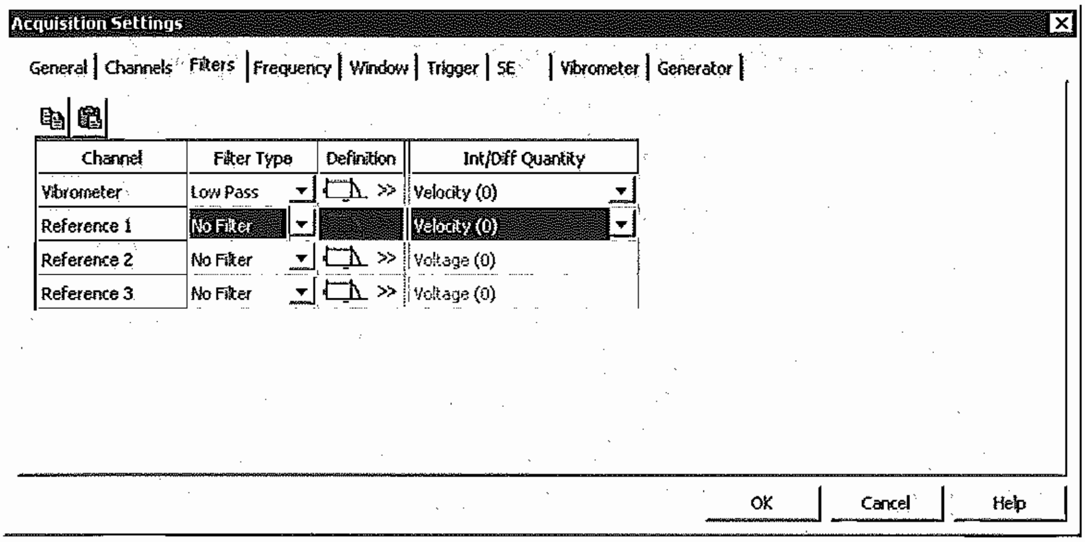


Figure 6.3: Page Filters, part 1 to select the filter

Filter Type: Here you select the type of filter to limit the bandwidth.

Definition: You click here to set the filter parameters to limit the bandwidth. The second part of the page Filters appears (see below).

Int/Diff Quantity: Using digital filters, the software can integrate or differentiate the time signal of some measured quantities. Here you select the physical quantity the software is to calculate. The number on the right next to the quantity tells you which arithmetic operation is being carried out, refer to TABLE 6.1.

Table 6.1: Filters for integration/differentiation

Number	Arithmetic operation
1	Integrate once
0	No filter
-1	Differentiate once
-2	Differentiate twice

☞ During integration and differentiation a time delay of half the sample interval occurs (sample interval = 1/sample frequency). This leads to a frequency-dependent phase shift. In case of a differentiation done twice, no time delay occurs.

Set the parameters

In the second part of the page Filters you set the filter parameters to limit the bandwidth. There you can define the filters for several channels one after the other.

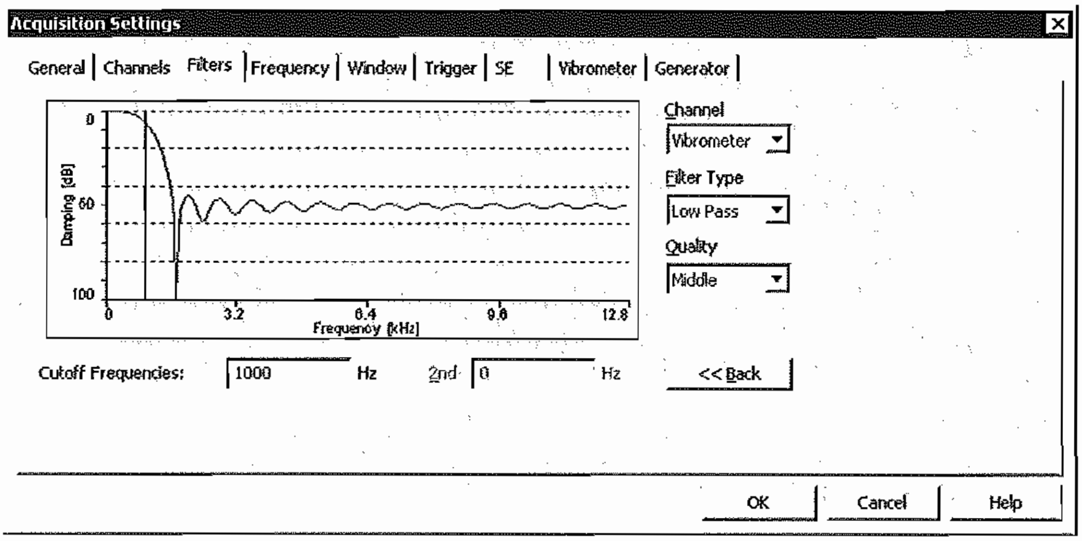


Figure 6.4: Page Filters, part 2 to set the parameters

Channel: Here you select the channel you want to set the filter for.

Filter Type: Select the type of filter here.

Quality: Here you select the quality of the filter.

Cutoff Frequencies: Enter the cutoff frequency(/ies) of the filter here in Hertz.

The software uses the parameters set to calculate the frequency response and displays it.

To apply all settings, at the bottom right, click Back. The software returns to the first part of the page Filters (see above).

6.2.4 Frequency

You set the parameters for calculating the frequency spectra on the pages Frequency and Window. In the measurement mode Zoom-FFT, the page Frequency is adapted to the Zoom-FFT. See SECTION 6.2.10 on this. In measurement mode MultiFrame, additional parameters appear on the page for the MultiFrame measurement. See SECTION 6.2.14 on this.

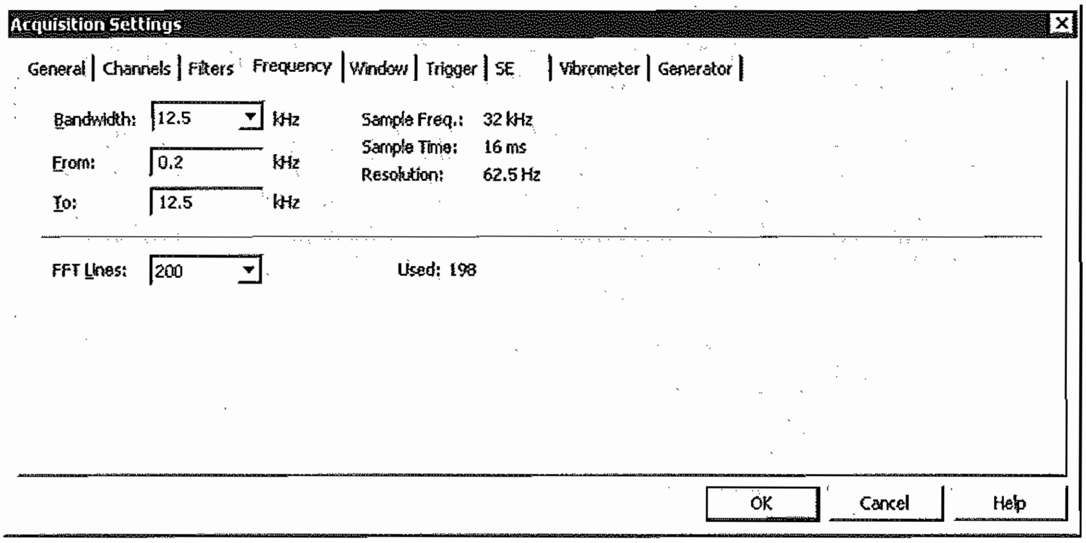


Figure 6.5: Page Frequency in measurement mode FFT

Frequency range

At the top left you set the frequency range to be measured.

Bandwidth: Here you select the bandwidth in kilohertz (kHz).

☞ With the UHF, here you select the bandwidth in megahertz (MHz). If you select 2000MHz as the bandwidth (only with option 1.2GHz Bandwidth (UHF)), you receive an additional message that the bandwidth extension is active. The bandwidth extension makes sense for small amplitudes or low velocities.

From and To: Here you can limit the frequency range which is displayed and evaluated. If you control a function generator using the software, then with the waveforms Periodic Chirp, Pseudo Random, Burst Random, and White Noise, excitation only takes place in this frequency range.

☞ With the UHF, the frequency range for the bandwidths 1000MHz and 2000MHz is limited for technical reasons (0MHz...610MHz or resp. 0MHz...1230MHz).

FFT

At the bottom you set the parameters for the Fast Fourier Transformation (FFT).

FFT Lines: Here you select the number of FFT lines that you want to analyze (up to 6400 or up to 12800 as an option).

☞ As an option to the 12800 FFT lines, you can still select up to 819200 FFT lines. Please note that if you are using this high number of FFT lines together with selecting many channels, your system can use its full capacity. Depending on the configuration of your system it is then not possible to use all settings.

Used: The number of FFT lines shown here corresponds to the frequency range between From and To (see above).

Overlap: This parameter only appears for certain hardware configurations in the measurement modes FFT and Zoom-FFT. The software only takes the parameter into account for measurements with averaging and without trigger. With overlap you can significantly reduce the time for a measurement, in particular for narrow bandwidths. As a rule of thumb, for a two-channel measurement, the following applies:

- Up to 2.5kHz bandwidth: 75% overlap
- From 2.5 to 5kHz: 50%
- Over 5kHz: 0%.

You will find more information on overlap in your theory manual.

Sample frequency and resolution

The software calculates the following parameters and shows them at the top right.

Sample Frequency: $f_{Sample} = 2.56 \cdot BW$ Equation 6.1

BW... Bandwidth

Sample Time: $t_{Sample} = \frac{n_{FFT}}{BW}$ Equation 6.2

n_{FFT}... Number of FFT lines
BW... Bandwidth

Resolution: $\Delta f = \frac{1}{t_{Sample}}$ Equation 6.3

t_{Sample}... Sample time

Max. Velocity: This parameter only appears with the option VDD. Due to the processing power of the PC, when using the option VDD only signals up to this maximum vibrational velocity can be acquired. The value depends on the bandwidth and the number of FFT lines (see above).

6.2.5 Window

You set the parameters for calculating the frequency spectra on the pages Frequency and Window.You set windowing of the input signals on the page Window. With suitable windowing you can prevent leakage. You will find information on this in your theory manual.

Work in the table

To accelerate adjustment of the settings, you can use the icons (Copy) and (Insert) above the table. To do so, tick the required cell(s), line(s) or column(s) as described in the following. Then click , mark the cell(s), line(s) or column(s) which you want to transfer the settings to and click .

Or:

Click with the right mouse button and select Copy or Insert in the context menu.

- To mark a cell, click it.
- To mark a line, click the first cell of this line.
- To mark a column, click the head of this column.
- To mark several consecutive cells, lines or columns, hold the shift key pressed and mark the first and last cell/start of line/column head with the mouse.
- To mark several cells, lines or columns which are not consecutive, hold the control key pressed and mark the respective cells/starts of line/ column heads with the mouse.
- If you want to mark the whole table, click the cell Channel.

In the same way you can copy settings to and from Microsoft® Excel.

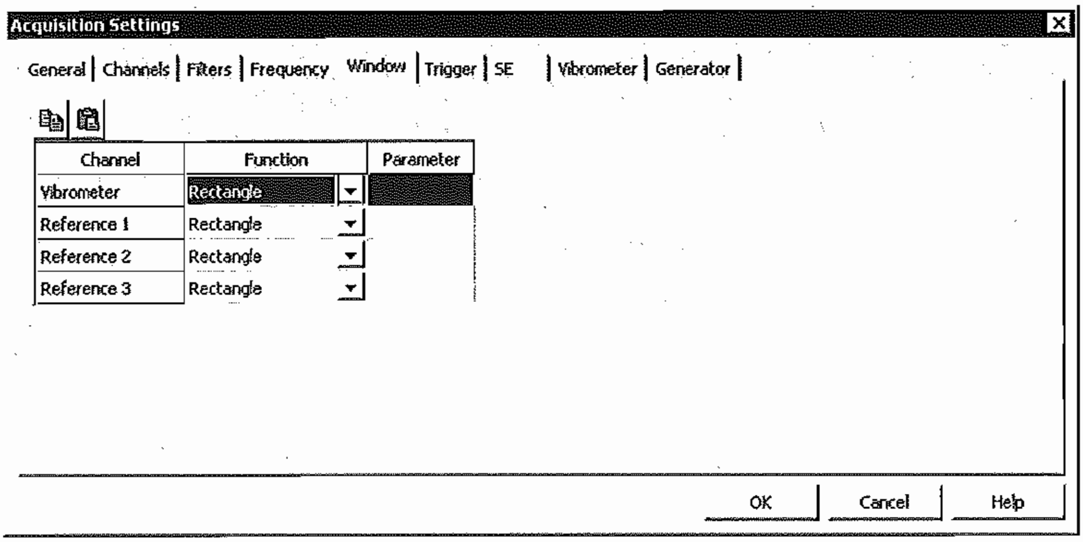


Figure 6.6: Page Window

Function: Here you select a window function which is suitable for your application. See your theory manual on this.

Parameter: The window functions Tapered Hanning, Force and Exponential can be fine-tuned with a parameter. In TABLE 6.2, the parameters are described.

Table 6.2: Parameters for window functions

Window function	Description of the parameter	Default
Tapered Hanning	Rise and decay time in percent of the sample time	10
Force	Length of the window in percent of the sample time	5
Exponential	Quotient from window length and decay constant	4

6.2.6 Trigger

You set the parameters for triggering on the page Trigger. You will find information on the influence of the trigger in your theory manual.

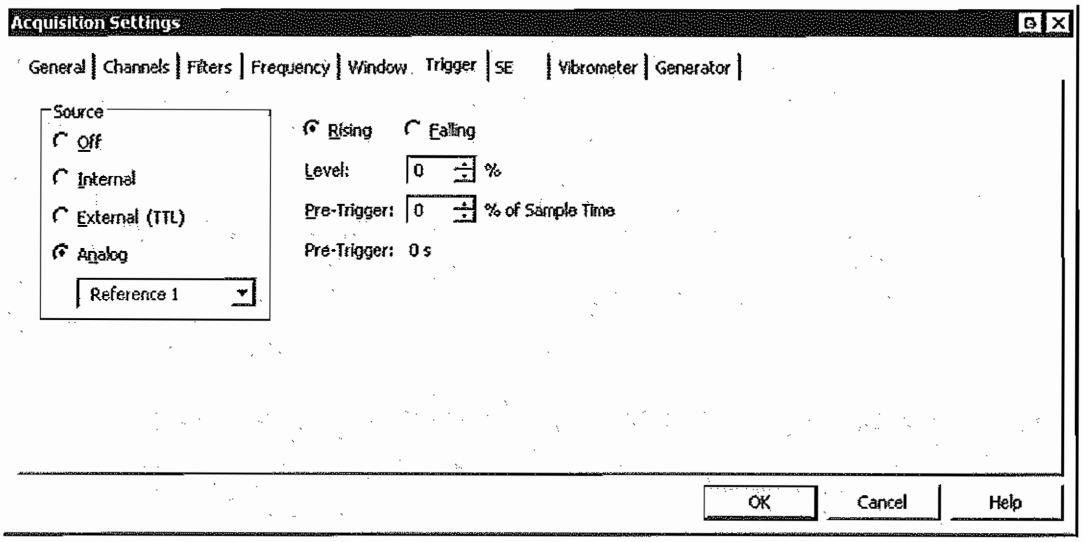


Figure 6.7: Page Trigger

Source

On the left you select the trigger source.

Off: You measure without a trigger.

☞ To measure phases you need a trigger or a reference signal.

Internal: You trigger on the synchronization pulse of the internal generator. To do this, you do not need a cable connection to the junction box.

☞ Using the internal trigger signal is only available for the following data acquisition systems:
PSV-400-B (PCI-4461); PSV-400-H4 (PCI-4462 + PCI-6711);
PSV-400-M2 (PCI-6111); PSV-400-M4 (PCI-6110) as well as
PSV-400-3D-H (PCI-4462 + PCI-6711) and PSV-400-3D-M (PCI-6110)

External (TTL): You trigger on an external trigger signal.

☞ Depending on the data acquisition board, using external trigger signals is not available for all bandwidths or sample frequencies (refer also to TABLE 6.3).

CAUTION!
Danger from too high voltage! - Only connect voltages in the range of 0 to 5V to the input for the external trigger! Otherwise you could damage the data acquisition board.

Analog: You trigger on one of the analog input signals. Select the channel the trigger signal is connected to below.

☞ When scanning, do not trigger on the vibrometer signal.

Conditions

On the right you set the trigger conditions.

Rising or **Falling:** Here you select which edge is used to trigger.

Level: If you trigger using one of the analog input signals, you set the trigger threshold here. 100% threshold corresponds to the input range of the channel (refer to SECTION 6.2.2).

Pre-trigger: Here you set the trigger time. If the data acquisition is to start **before** the trigger time, enter a positive value. If data acquisition is to start **after** the trigger time (Post-Trigger), enter a negative value.

☞ There are no limitations to using the analog and the internal trigger. You will find the limitations for using the external trigger in the following table. If you do not keep the limitations, the external trigger will be switched off.

Table 6.3: Limitations for using the external trigger

System	Data acquisition board	Limitation
PSV-400-B	PCI-4451	no limitation
PSV-400-B	PCI-4461	only up to 12800 FFT lines only up to 1048576 samples
PSV-400-H4	PCI-4452	only up to 40kHz bandwidth or only up to 102.4kHz sample frequency
PSV-400-H4	PCI-4462	only up to 12800 FFT lines only up to 1048576 samples
PSV-400-M2	PCI-6111	no pre-trigger
PSV-400-M4	PCI-6110	no pre-trigger
PSV-400-M2-20	MI.3025	> 2MHz bandwidth: no limitation ≤ 2MHz bandwidth: no pre-trigger
PSV-400-M2-20	M2i.3027	> 2MHz bandwidth: no limitation ≤ 2MHz bandwidth: no pre-trigger
PSV-400-3D-H	PCI-4452	only up to 40kHz bandwidth or only up to 102.4kHz sample frequency

Table 6.3: Limitations for using the external trigger

System	Data acquisition board	Limitation
PSV-400-3D-H	PCI-4462	only up to 12800 FFT lines only up to 1048576 samples
PSV-400-3D-M	PCI-6110	no pre-trigger
MSA-500-M2	PCI-6111	no pre-trigger
MSA-500-M2-20	MI.3025	> 2 MHz bandwidth: no limitation ≤ 2 MHz bandwidth: no pre-trigger
MSA-500-M2-20	M2i.3027	> 2 MHz bandwidth: no limitation ≤ 2 MHz bandwidth: no pre-trigger
UHF-120	LeCroy wavePro	no limitation
MSA-400-M2	PCI-6111	no pre-trigger
MSA-400-M2-20	MI.3025	> 2 MHz bandwidth: no limitation ≤ 2 MHz bandwidth: no pre-trigger
MSA-400-M2-20	M2i.3027	> 2 MHz bandwidth: no limitation ≤ 2 MHz bandwidth: no pre-trigger
MSV-400-M2	PCI-6111	no pre-trigger
MSV-400-M2-20	MI.3025	> 2 MHz bandwidth: no limitation ≤ 2 MHz bandwidth: no pre-trigger
MSV-400-M2-20	M2i.3027	> 2 MHz bandwidth: no limitation ≤ 2 MHz bandwidth: no pre-trigger
PSV-300-U	PCI-4451	no limitation
PSV-300-H	PCI-4452	only up to 40 kHz bandwidth or only up to 102.4 kHz sample frequency
PSV-300-F	PCI-6111	no pre-trigger
MSV-300-F	PCI-6111	no pre-trigger
MSV-300-M	MI.3025	> 2 MHz bandwidth: no limitation ≤ 2 MHz bandwidth: no pre-trigger

Gate signal (as an option)

As an option, you can control data acquisition with an external gate signal. You will find information on this in your hardware manual. You do not have to set special parameters for this.

☞ With the UHF, the gate signal is used to control the laser. The signal switches the laser to full power for making measurements. Thus, enter an appropriate negative value for the Pretrigger so that the Posttrigger is set to minimum 5.5 µs.

6.2.7 Signal Enhancement (SE)

On the page SE you set the parameters for Signal Enhancement (SE) and Speckle Tracking. When scanning, with Signal Enhancement and Speckle Tracking, you get an approximately even noise level for all scan points. You will find information on measuring with Signal Enhancement in SECTION 7.8.1 and in your theory manual.

☞ If you want to mark the whole table, click the cell Channel.

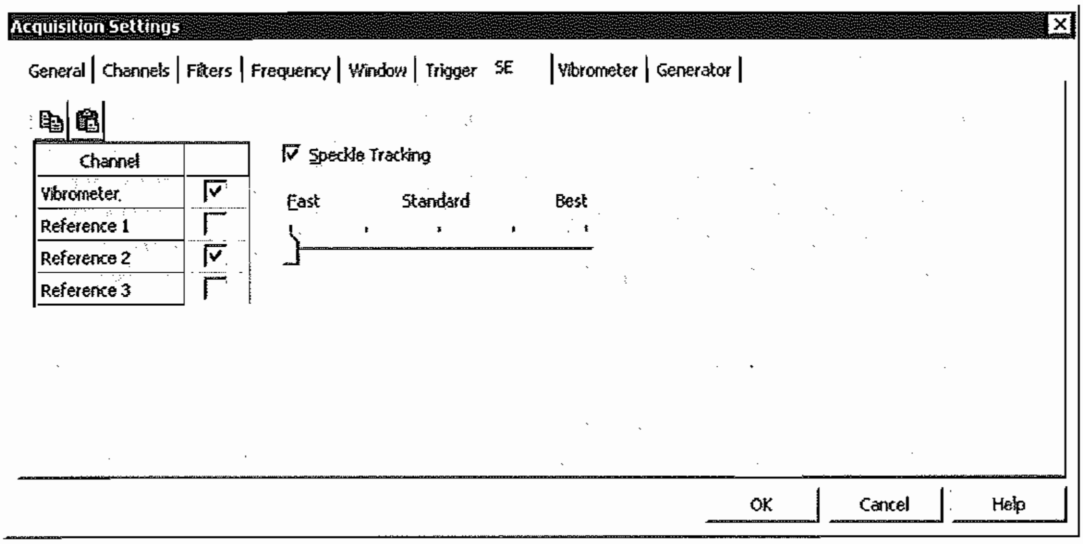


Figure 6.8: Page SE

☞ The measurement mode Time is an exception. The dialog page SE only appears if on the page General you have set Time for Averaging. This page always appears for PSV-400-H4 and PSV-400-3D-H .

Activate

On the left you can activate Signal Enhancement.

☞ Measurement mode Time with averaging Time: With active SE, a median algorithm is used for averaging. This makes higher demands on your PC with regards to memory and calculation speed.

Channel: Here you mark the channels which Signal Enhancement is to be active for. For PSV-400-H4 and PSV-400-3D-H you also activate the dropout recognition and removal (only in measurement mode Time). You will find more information on this in SECTION 7.8.1.

☞ Activate Signal Enhancement for all channels which may have dropouts. This is generally the case for the vibrometer channel. For reference channels, the following applies: If a vibrometer is connected, measure on treated surfaces if possible and switch Signal Enhancement off. To treat surfaces, stick reflective film on them or apply metallic paint. If you are measuring with the vibrometer, but not on treated surfaces, activate Signal Enhancement.

Speckle Tracking: If Signal Enhancement is active for the vibrometer channel, then you can activate Speckle Tracking for this channel on the right. Without Speckle Tracking, every scan point is measured at the same position when averaging. So it is possible that you will always measure a dark speckle. With Speckle Tracking, the position of every scan point is slightly changed on averaging - at a 1 meter stand-off distance by about 50µm. You are then also quite likely to measure some bright speckles.

☞ With the UHF, no Speckle Tracking is available.

Average

At the right you set how often additional averaging is carried out with Signal Enhancement.

☞ Please note that spectra and time signals with the Scan Status Overrange are not taken into account when averaging. But if all spectra previously acquired have the status Overrange, then first of all these spectra will be averaged and displayed. Only when the first spectrum will be captured without Overrange, the average counter is reset and the previously measured spectra with the status Overrange are rejected. Any other spectra with the status Overrange are then also rejected.

Fast: Averaging is only carried out as often as set on the page General (refer to SECTION 6.2.1).

Standard: Depending on the optical signal level, averaging is carried out up to three times as often as set.

Best: Averaging is carried out up to five times as often as set.

In the measurement mode Time, the number of times averaging is carried out always corresponds to the figure given on the page General.

6.2.8 Vibrometer

You set the parameters of the controller for data acquisition on the page Vibrometer. You will find information on suitable settings in your hardware manual. If you are controlling a second vibrometer, then you set the parameters for both controllers on the page Vibrometer. You will find information on controlling a second vibrometer in SECTION 7.8.6.

The parameters displayed on the page Vibrometer depend on which controllers are connected (refer to SECTION 3.2). The parameters for the controllers OFV-5000 and also OFV-3001 and OFV-3001S are described below. If you would like any information on other controllers, refer to your vibrometer manual. There you will also find information on suitable settings.

☞ With the UHF, the page Vibrometer will be displayed, but you can not set any parameters for the controller.

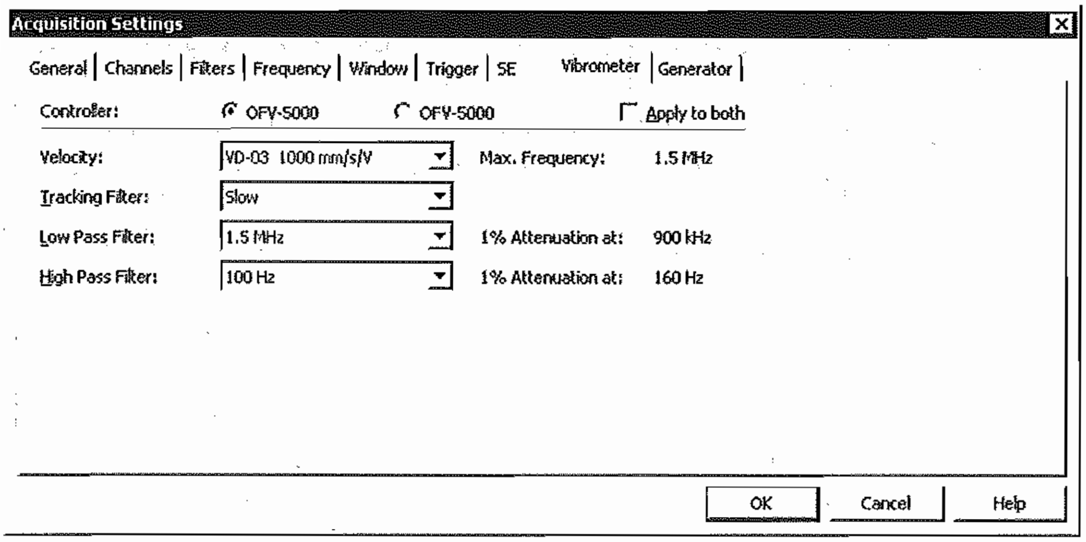


Figure 6.9: Page Vibrometer for the controller OFV-5000

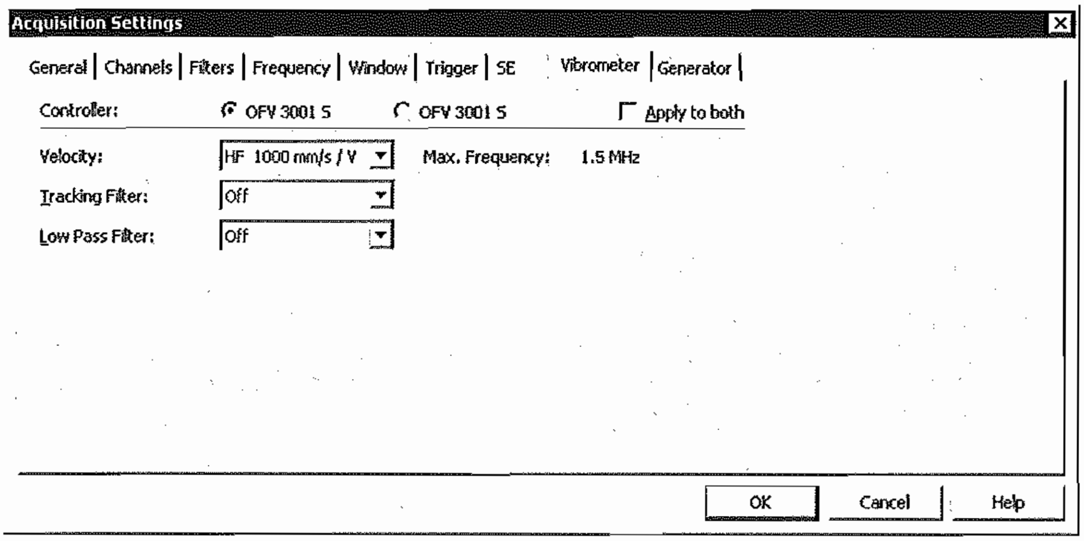


Figure 6.10: Page Vibrometer for the controller OFV-3001 S

Controller: Here you can select the controller which the settings are to apply to. If there are two controllers installed, you can switch between the two of them and define the settings for each of them individually.

☞ Only OFV-5000 as of firmware version 2.0:
The software queries the time delay of the measurement range set on the vibrometer controller. The time delay is used to correct the phase of the spectra. The high and low pass filter should be left switched off as their delay times are not being corrected.
The correction can only be made approximately. The remaining phase error in the acoustic area is up to 3° and increases for frequencies above 20 kHz with increasing frequency up to 35°.
In the time domain this correction is not active!

Apply to Both: If both controllers are identical, i.e. the same type and equipped with identical decoders, then the settings for one can be transferred directly to the other. To do so, mark the box.

Velocity: Here you select the measurement range for the velocity. For the controller OFV-5000, the decoder descriptions are shown in plain text. OFV-3001 and OFV-3001S: If a measurement range is available in several velocity decoders, then to the left of the measurement range you can see an abbreviation for the active velocity decoder. The abbreviations are explained in TABLE 6.4.

Table 6.4: Abbreviations for velocity decoders in the OFV-3001/OFV-3001S

Abbreviation	Velocity decoder
HF	OVD-02 OVD-04
LF	OVD-06
DC	PLL-DC
PLL	OVD-01

Displacement: This line only appears if the controller is equipped with an optional displacement decoder. Here you select the measurement range for the displacement.

☞ Even if you are only measuring and evaluating the displacement signal, the measurement range for the velocity must not be exceeded (see above).

Tracking Filter: Here you set the tracking filter.

Low Pass Filter: Here you set the low pass filter. Only PSV-300-H and PSV-200-1: If you select the setting User Defined, then the field Cutoff Frequency appears at the bottom. There you can enter multiples of 0.4 kHz, up to a maximum of 102.4 kHz.

☞ The settings for the low pass filter and the high pass filter have only an effect on the velocity output (VELOCITY OUTPUT).

High Pass Filter: Here you set the high pass filter.

☞ If you are using the vibrometer to scan, switch the high pass filter off.

Max. Frequency: Here the respective maximum frequency is shown for the selected measurement range.

1% Attenuation at: Here the frequency of the 1% attenuation of the measurement signal is shown for the selected low pass filter or high pass filter respectively.

6.2.9 Generator (as an Option)

As an option, you can control certain function generators using the software. You will find information on this in SECTION 7.8.2 and SECTION 7.8.3. You set the parameters for signal output on the page Generator.

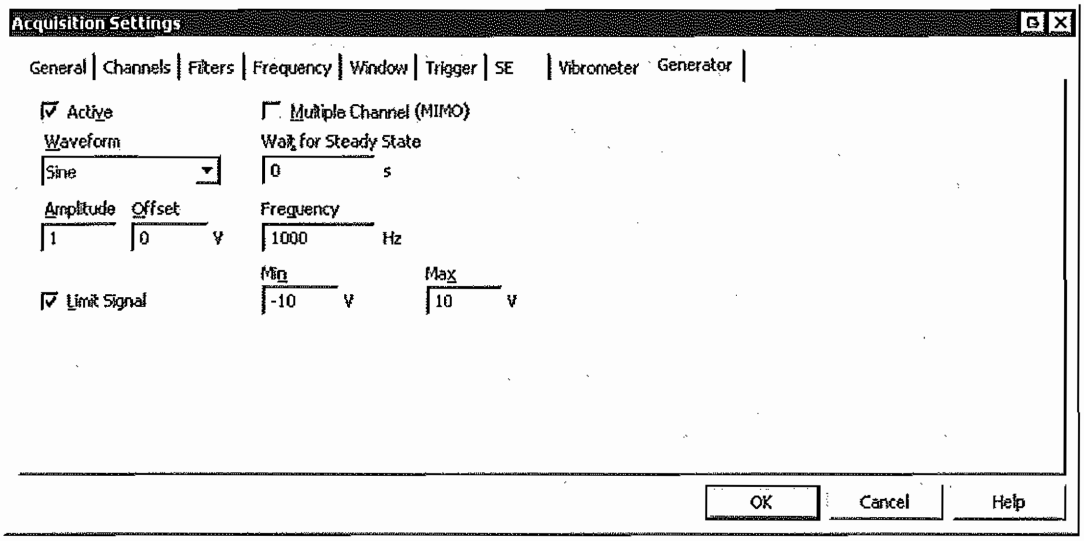


Figure 6.11: Page Generator

General parameters

Active: If sometimes you are not working with the function generator, you can switch it off here for the software. Otherwise signal output starts automatically when scanning. Apart from that, you will suppress corresponding warnings and error messages.

Multiple Channel (MIMO): Only PSV-400-H4 and PSV-300-H: You activate three generator channels here.

☞ Using the junction box PSV-E-401 or PSV-E-401-3D four generator channels are available to you.

For signals with randomly generated numbers (Pseudo Random, White Noise, Burst Random), different signals are generated using various random number sequences, otherwise identical signals on all three channels. You will find more information on this in SECTION 6.2.2.

☞ If you want to carry out a principal component analysis, you have to mark the box Multiple Channel (MIMO) (only with option PCA, refer also to SECTION 6.2.1) and select White Noise or Burst Random. Uncorrelated signals are only emitted with these waveforms.

Waveform: Here you select the waveform you want to emit. Some parameters on the page Generator change with the waveform selected. You will find an explanation of these parameters and information on some of the waveforms in the following. In the measurement mode FastScan, a sinusoidal signal with the frequency of the FastScan is always used for excitation.

Wait for Steady State: Here you enter the time in seconds which the excited object needs to attain steady-state condition. The software delays data acquisition by this time after you have

- started signal output or
- closed the dialog Acquisition Settings with OK.

☞ The signal generation is made during this waiting period.

Amplitude and **Offset:** Here you enter the peak amplitude and DC offset of the signal in volts for high-impedance termination of the function generator. The following conditions must be fulfilled:

$$\text{Magnitude} + |\text{Offset}| \leq 10\ \text{V} \qquad \text{Equation 6.4}$$

Only 33120A and 33250A:

$$|\text{Offset}| \leq \text{Magnitude} \qquad \text{Equation 6.5}$$

If one of the conditions is not fulfilled, the software changes the offset.

☞ Many function generators such as the HP or the internal function generator have an output impedance of 50 Ω. If you terminate such a function generator with 50 Ω, then the output voltages are only half the size set.
This is of particular importance for spectrum generators which have an output impedance of < 1 Ω. The data acquisition board of Spectrum is preset to be terminated with 50 Ω (default setting). To change the setting to 1 MΩ, display the page Channels in the dialog Acquisition Settings (refer to SECTION 6.1).
Only for external function generators: The display of the generator shows peak-to-peak amplitude and offset for the termination with 50 Ω. With high-impedance termination the display shows twice the applied voltage at the output.

Limit Signal: Tick this box if you want to limit the signal strength of the generator signal. This allows you to protect sensitive components. Enter the appropriate values for Min and Max. The software takes both these limits and also the offset into account for the slider of the generator amplitude in the scanning head control. Refer to SECTION 4.1.1 on this as well under Show Channels.

Amplifier: This check box only appears for MSA and MSV-M2-20 systems with the generator board MI.6030 or resp. M2i.6030 by Spectrum. Mark the box to increase the voltage of the generator output from ±3V to ±10V.

Sine, Rectangle, Triangle, Ramp

Frequency: For the waveforms Sine, Rectangle, Triangle and Ramp, you enter the repeat frequency of the signal in hertz here.

Sweep

Start Frequency, End Frequency and **Sweep Time:** For a Sweep, you enter the start and end frequency in hertz here. The start frequency can be higher than the end frequency. You also enter the duration of the sweep in seconds.

Periodic Chirp, Pseudo Random

For the waveforms Periodic Chirp and Pseudo Random, sinusoidal signals are emitted to all FFT lines at the same time, but only in the frequency range between From and To on the page Frequency (refer to SECTION 6.2.4).
Only 33250A: The waveforms are not available in the measurement mode Zoom-FFT.
Only 33120A: The waveforms are not available in the measurement mode Zoom-FFT or if 12800 FFT lines are set.

With Periodic Chirp, the phases of the sinusoidal signals are adapted so that the energy of the resulting signal is maximized. With Pseudo Random, the phase of the sinusoidal signals is random.

Amplitude Correction File: As standard, with Periodic Chirp and Pseudo Random all sinusoidal signals have the same amplitude. If you need other amplitudes or frequencies, you can generate a correction file and list it here. To do this, tick the box and then click Browse. The dialog Open appears, in which you can navigate to correction files. You will find a short description of the format required in the file AmplitudeCorrectionSample.txt in the directory Examples (shortcut on the desktop). You can also use this file as a template for your own correction files.

Burst Chirp, Burst Random

The waveforms Burst Chirp and Burst Random are only available for certain hardware configurations. The number of samples for Burst Random is limited to 524288 (1/2 Megasample).

☞ For the waveform Burst Random, signals are emitted only in the frequency range between From and To on the page Frequency (refer to SECTION 6.2.4).

Start Frequency and **End Frequency:** For a Burst Chirp, you enter the start and end frequency in hertz here. The start frequency can be higher than the end frequency.

Burst Start and **Burst Length:** Here you enter when the burst is to start and how long it is to last (input in percent of the sample time).

White Noise

For the waveform White Noise, signals are emitted only in the frequency range between From and To on the page Frequency (refer to SECTION 6.2.4).

User Defined

Frequency: For the waveform User Defined, you enter the repeat frequency of the signal in Hertz here.

Browse: If you need other waveforms, you can generate them yourself. You will find a short description of the format required in the file UserDefSample.txt in the directory Examples (shortcut on the desktop). You can also use this file as a template for waveforms you want to generate. To load a waveform you have generated, select the waveform User Defined and then click Browse. The dialog Open appears, in which you can navigate to files you have generated.

6.2.10 Frequency in the Measurement Mode Zoom-FFT (as an Option)

In the measurement mode Zoom-FFT you can also make high-resolution FFT measurements. To do this, you need the option Zoom-FFT. The page Frequency is then adapted to the Zoom-FFT.

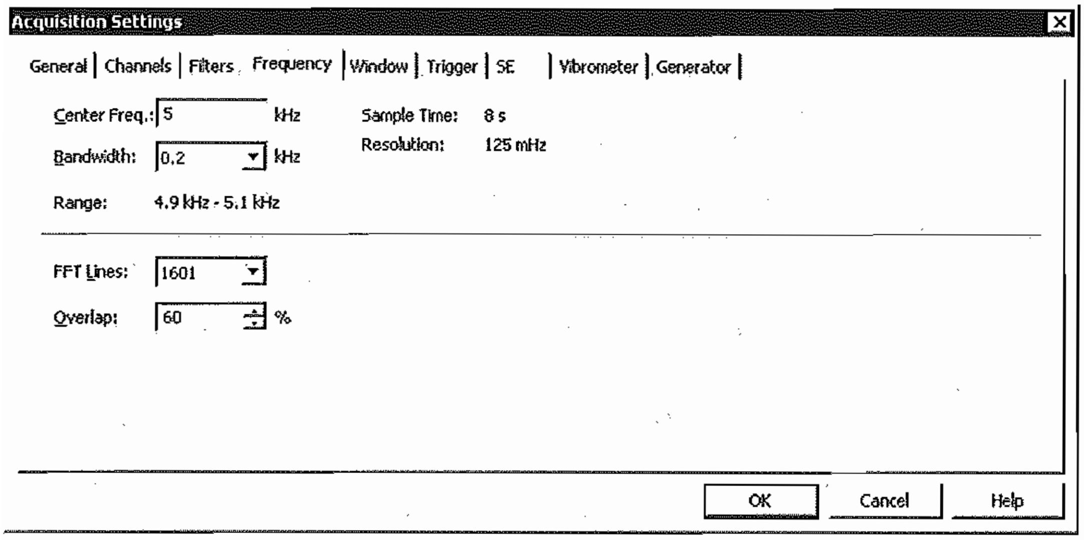


Figure 6.12: Page Frequency in the measurement mode Zoom-FFT

Frequency range

At the top left you set the frequency range to be measured.

Center Freq. Here you enter the center frequency in kilohertz.

Bandwidth: Here you select the bandwidth in kilohertz.

☞ For PSV/MSA/MSV-400-M2-20 and MSV-300-M you can only use frequencies up to 2 MHz.

Range: The software calculates the frequency range to be measured and shows it here.

FFT

At the bottom you set the parameters for the Fast Fourier Transformation (FFT).

FFT Lines: Here you select the number of FFT lines that you want to analyze. The number is odd because the frequency range measured is symmetrical about the center frequency.

Overlap: This parameter only appears for certain hardware configurations. You will find information on this in SECTION 6.2.4 and in your theory manual.

Resolution

The software calculates the following parameters and shows them at the top right.

Sample Time:

$$t_{Sample} = \frac{n_{FFT} - 1}{BW} \quad \text{Equation 6.6}$$

n_{FFT} ... Number of FFT lines
BW ... Bandwidth

Resolution: $$\Delta f = \frac{1}{t_{Sample}}$$ Equation 6.7

t_{Sample} ... Sample time

☞ The highest attainable resolution depends on the frequency range measured (see above).

Max. Velocity: This parameter only appears with the option VDD. Due to the processing power of the PC, when using the option VDD only signals up to this maximum vibrational velocity can be acquired. The value depends on the bandwidth and the number of FFT lines (see above).

6.2.11 FastScan (as an Option)

In the measurement mode FastScan you can scan individual frequencies quickly. You will find information on this in SECTION 7.8.4. You set the parameters for this on the page FastScan.

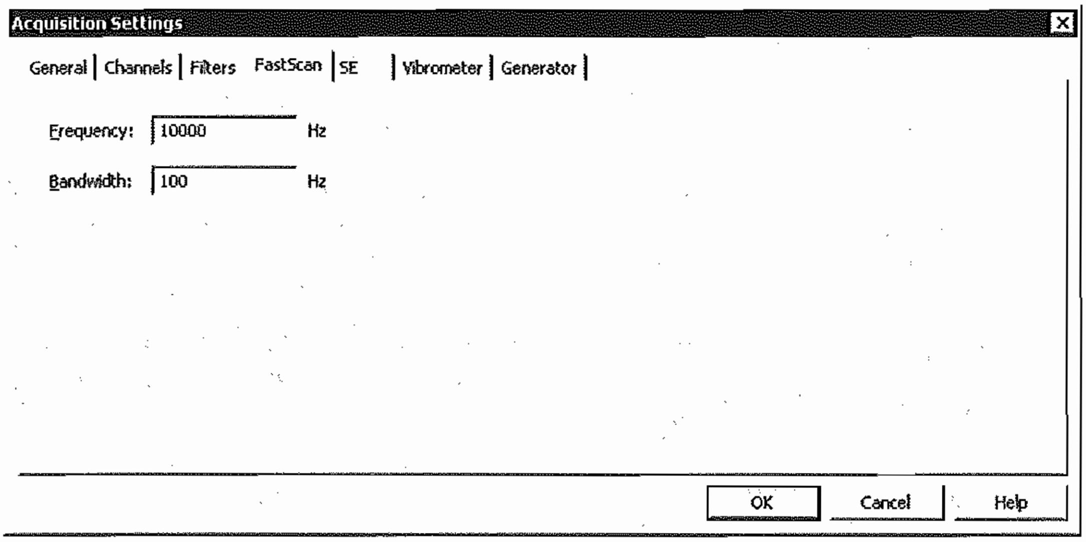


Figure 6.13: Page FastScan

Frequency: Here you enter the frequency in hertz at which you want to fast scan.

☞ If you control a function generator using the software, then in the measurement mode FastScan, a sinusoidal signal at the FastScan frequency is always used for excitation.

Bandwidth: Here you enter the bandwidth in hertz. As a general rule it can be said: The smaller the bandwidth, the better the signal-to-noise ratio, but the slower the scan.

Max. Velocity: This parameter only appears with the option VDD. Due to the processing power of the PC, when using the option VDD only signals up to this maximum vibrational velocity can be acquired. The value depends on the bandwidth and the number of FFT lines (see above).

6.2.12 Time (as an Option)

In the measurement mode Time you can save time signals instead of spectra for scans. To do this, you need the option Time Domain Data. You can select up to 64 Megasamples (67 108 864 samples). However, please note that the amount of memory required increases with the number of samples. The minimum disk space a measurement requires can be approximated using the following formula:

File size in bytes > Active channels · Number of samples · 4

Depending on the number of samples and the hardware configuration, there are limitations on the generator signals Burst Chirp, Burst Random and White Noise. In this case the software will give you corresponding messages. Either reduce the number of samples or select a different excitation signal (see also SECTION 6.2.9 on this).

For PSV/MSA/MSV-400-M2-20 the maximum number of samples from a sample frequency of 10.24 MHz upwards is limited by the memory of the data acquisition board. The higher the sample frequency you select, the more samples are possible.

The software will try to use the main memory during data acquisition to buffer the acquired data.

While the contents of the buffer are being transferred to the hard disk, so-called buffer overruns can occur which lead to the data acquisition being aborted. All data which had been acquired before this point in time however will be saved. So make sure that your PC has got a large enough main memory (RAM). In an ideal case this is 64 MB more than the file size calculated above. If the size of the main memory used (RAM) should not be sufficient, the software will issue you with a warning. If possible, close all other applications during data acquisition.

Data acquisition in the measurement mode Time generates extremely large files with numerous samples. Once the file size has reached 2 GB, the software will give you a warning.

You set the parameters for the measurement mode Time on the page Time.

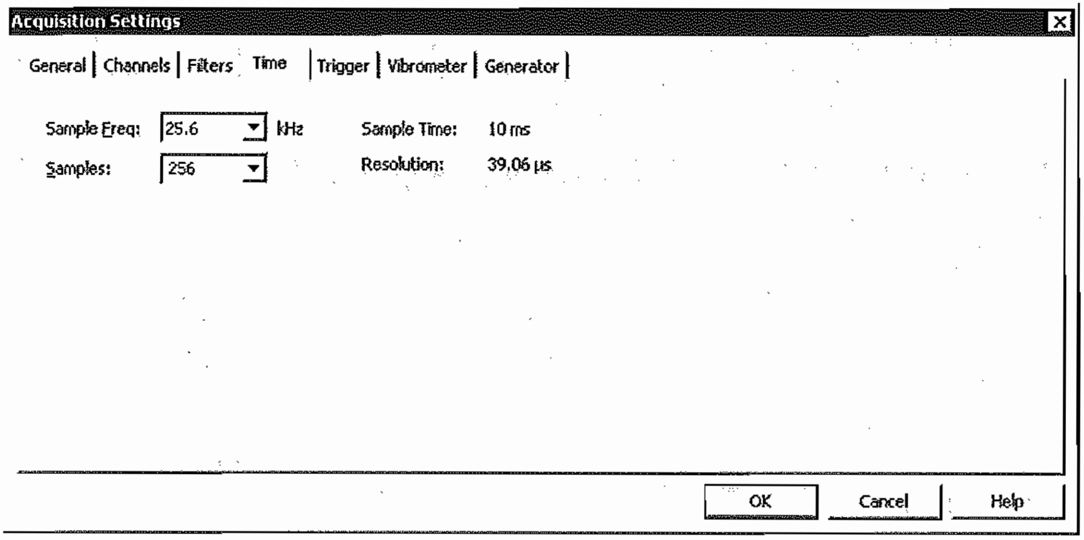


Figure 6.14: Page Time

Sample Freq. Here you select the sample frequency in kilohertz.

☞ With the UHF, here you select the sample frequency in megahertz (MHz). If you select 5000MHz as the sample frequency (only with option 1.2GHz Bandwidth (UHF)), you receive an additional message that the bandwidth extension is active. The bandwidth extension makes sense for small amplitudes or low velocities.

Samples: Here you select the number of samples. You can select in the list or enter any number.

The software calculates the following parameters and shows them on the right.

Sample Time:

$$t_{Sample} = \frac{n_{Sample}}{f_{Sample}} \qquad \text{Equation 6.8}$$

n_{Sample} ... Number of samples

f_{Sample} ... Sample frequency

Resolution:

$$\Delta t = \frac{1}{f_{Sample}} \qquad \text{Equation 6.9}$$

f_{Sample} ... Sample frequency

Max. Velocity: This parameter only appears with the option VDD. Due to the processing power of the PC, when using the option VDD only signals up to this maximum vibrational velocity can be acquired. The value depends on the sample frequency and the number of samples (see above).

6.2.13 MultiFrame (as an Option)

In the measurement mode MultiFrame you can divide measurements on combustion engines into frames and analyze the frames individually. You will find information on this in SECTION 7.8.5. You set the parameters for this on the pages MultiFrame and Frequency.

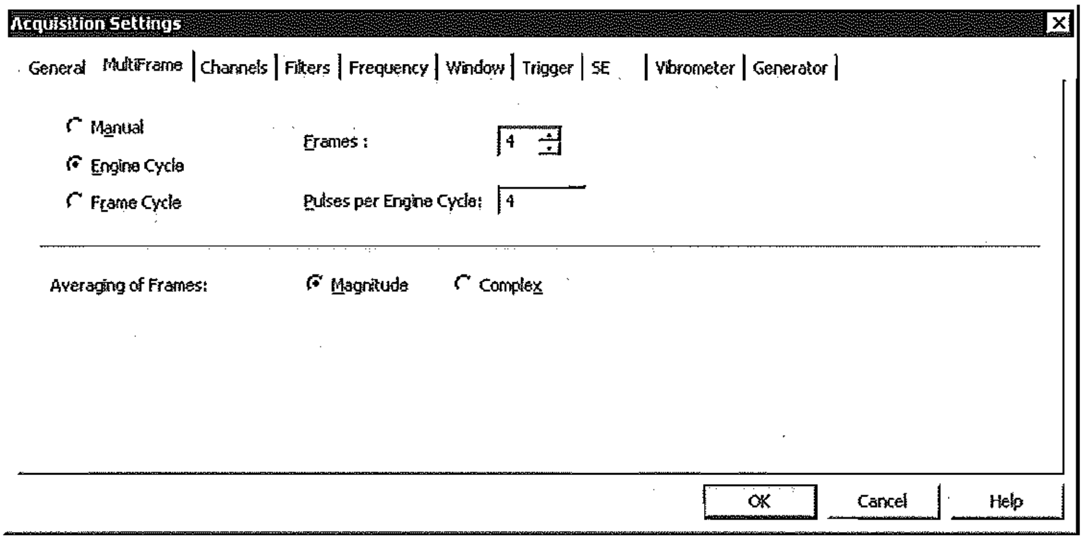


Figure 6.15: Page MultiFrame

Frame boundaries

At the top left you set how you determine the frame boundaries.

Manual: If you want to set the frame boundaries manually in the analyzer, select Manual. The start of the engine cycle is determined by a trigger signal at TRIG IN.

Engine Cycle: If the frame boundaries are to be set automatically by the engine cycle, select Engine Cycle. Start and end of the engine cycle are determined by a trigger signal (TTL, rising edge) at MultiFrame. All frames are the same length.

☞ If you select Engine Cycle or Frame Cycle, then MultiFrame is shown as the last channel. If you select Manual, then the last channel is available as a reference channel.

Frame Cycle: If the frame boundaries are to be set automatically by the frame cycle, select Frame Cycle. The start of the engine cycle is determined by a trigger signal (TTL, rising edge) at TRIG IN. A second trigger signal (TTL, rising edge) at MultiFrame ends the frame.

Number of frames

At the top right you set the number of frames and the pulses per cycle.

Frames: Here you enter how many frames an engine cycle has.

Pulses per Engine Cycle: Here you enter how many trigger pulses are emitted per engine cycle. If Frame Cycle is active (see above), the number of pulses per cycle must be an integer multiple of the number of frames.

Averaging of frames

You can analyze the spectra of the individual frames and the average of all frames. At the bottom you set how the software averages.

Magnitude or **Complex:** Here you select how the software averages over the frames. Averaging over the frames is independent of the averaging on the page General (refer to SECTION 6.2.1).

6.2.14 Frequency in the Measurement Mode MultiFrame (as an Option)

In the measurement mode MultiFrame you can divide measurements on combustion engines into frames and analyze the frames individually. You will find information on this in SECTION 7.8.5 and SECTION 6.2.13. On the page Frequency additional parameters then appear for MultiFrame measurements.

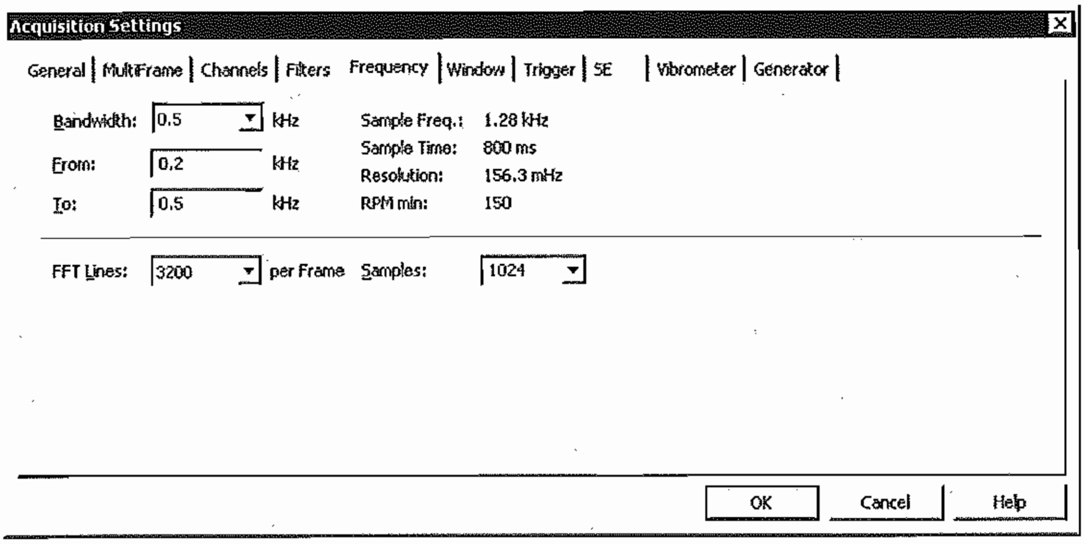


Figure 6.16: Page Frequency in the measurement mode MultiFrame

At the bottom right, set the number of samples.

Samples: Here you select the number of samples.

The software calculates the sample time and the lower RPM limit RPM_{min} which it can acquire with the parameters set and shows them on the right in the middle.

Sample Time:

$$t_{Sample} = \frac{n_{Sample}}{2.56 \cdot BW} \qquad \text{Equation 6.10}$$

n_{Sample} ... Number of samples
BW ... Bandwidth

RPM min:

$$RPM_{min} = \frac{120}{t_{Sample}} \qquad \text{Equation 6.11}$$

t_{Sample} ... Sample time

You will find information on the other parameters on the page Frequency in SECTION 6.2.4.

7 Making Measurements

You can make single point measurements and scan using the software. Please read SECTION 7.1 and SECTION 7.2 on this.

In the video window you can follow the progress of a scan. Read SECTION 7.3 on this.

In SECTION 7.4 you will find more over measurement options using PSV-3D.

When a measurement is running, the status bar can display messages on it. See SECTION 7.5 on this.

In SECTION 7.6 you will find information on what you have to pay attention to if you stop a measurement.

Only with option VDD: You must run the test mode at regular intervals before making measurements. See SECTION 7.7 on this.

In SECTION 7.8 you will find a few application examples which give you detailed instructions on various measurement tasks.

7.1 Single Point Measurement

You can make single point measurements as single shots or as a continuous measurement.

Single shot

With a single shot, the software makes a single measurement and then ends data acquisition. You can also stop single shots manually.

Continuous measurement

With a continuous measurement, the software repeats single shots until you manually stop data acquisition. You can only save the last single shot.

To make a single point measurement, proceed as follows:

Preparation

1. Go into acquisition mode. To do so, click ☀ or select View > Acquisition.
2. Set the software up for data acquisition as described in CHAPTER 3.
3. Set the optics and position the laser beam to point at the place where you want to make a measurement. See CHAPTER 4 on this.
4. Focus the laser beam (manually or automatically in the scanning head control). See SECTION 4.1 and SECTION 4.2 on this.
5. Only with option VDD: You must run the test mode at regular intervals before making measurements. See SECTION 7.7 on this.
6. Set the parameters for data acquisition. See CHAPTER 6 on this.

Start

7. Start a single shot or a continuous measurement. To do so, click or . You can also select Acquisition > Single Shot or Acquisition > Continuous.

Follow the measurement

8. During the measurement, you can display data in analyzers as described in SECTION 8.2 and SECTION 8.4.

9. During the measurement, the status bar and scanning head control can display messages on data acquisition. See SECTION 7.5 on this.

Stop

10. To stop the measurement, click or select Acquisition > Stop. Please see SECTION 7.6 on this as well.

7.2 Scanning

A scan is a sequence of single point measurements. The order in which the software approaches the scan points is determined by an internal algorithm. For every scan point, the software carries out the following steps:

- Position the laser beam at the scan point.
- Set the optics of the scanning head to the focus value of the scan point (only with option APS Professional, refer to SECTION 5.6).
- Wait for the end of the settling time of the scanner mirrors.
- Make a single shot.
- Assign scan point status.
- Save measurement data.

After a scan, the software can automatically remeasure certain scan points or you can start remeasuring manually. You can also mark single scan points in presentation mode to be remeasured and then remeasure this file in acquisition mode.

To scan, proceed as follows:

Preparation

1. Go into acquisition mode. To do so, click or select View > Acquisition.

2. Set the software up for data acquisition as described in CHAPTER 3.

3. Set the optics. See CHAPTER 4 on this.

4. Define and, if applicable, modify the scan points as described in CHAPTER 5. Here you determine whether you want to assign focus values automatically (Focusing during Scan). See SECTION 5.6.2 on this. In addition, here you select whether you want to carry out Video-Triangulation during Scan. See SECTION 5.4.2 on this.

5. Set the parameters for data acquisition. See CHAPTER 6 on this.

Start

6. Start the scan. To do so, click or select Acquisition > Scan. If the function generator is active (refer to SECTION 6.2.9), signal output starts. The software creates a file for the scan. The dialog Save As appears.

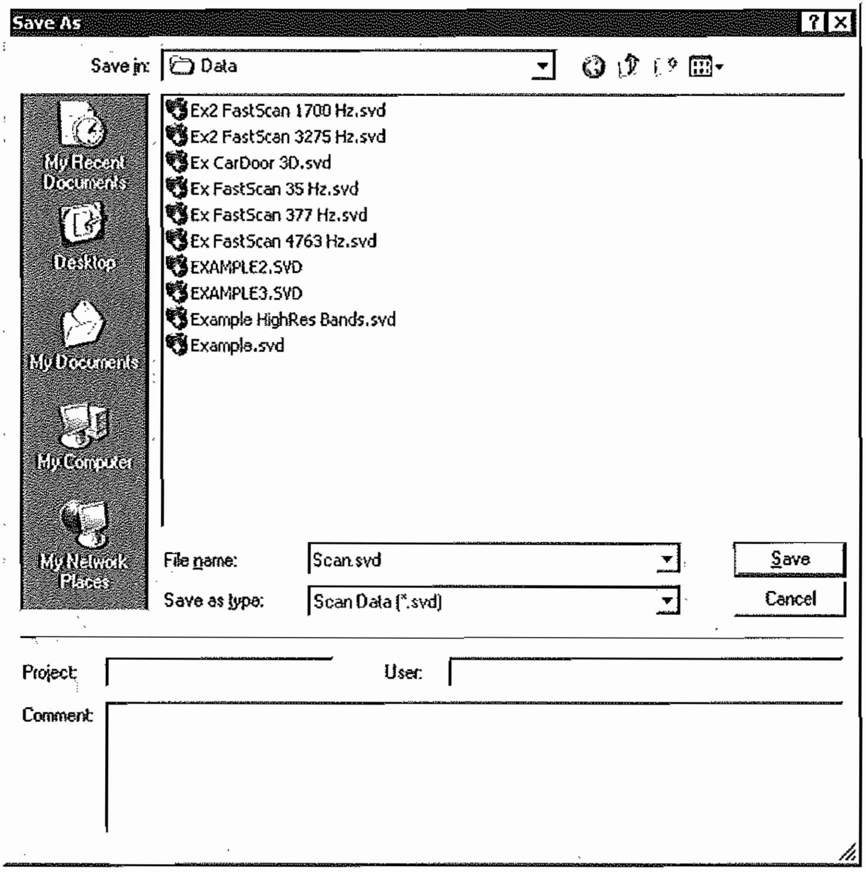


Figure 7.1: Dialog Save As

Save

7. Navigate to the saving location and enter the file name.

☞ If you have the project browser displayed (refer to SECTION 2.6.4), you will then automatically be shown the directory marked there as saving location.

8. At the bottom in the dialog you can enter additional information to give the file more precise properties. This information is part of the file properties which you can also view and edit in the Explorer. It will be displayed to you when you open a file in presentation and also in the dialog File Information (see also SECTION 2.6.4 on this).

9. Click Save. The scan starts. The software immediately saves every scan point measured.

☞ If you have selected the 3D view in acquisition mode, the software will change over to the 2D view on starting the scan. Thus you can follow the movement of the laser beam on the object in the live video image.

Follow the scan

10. You can follow the progress of the scan in the video window as described in SECTION 7.3. During the scan, you can display data in analyzers as described in SECTION 8.2 and SECTION 8.4.

11. During the scan, the status bar and scanning head control can display messages on the data acquisition. See SECTION 7.5 on this.

Stop the scan and continue

12. Once the total sample time has expired, the software ends data acquisition and displays a message. However, you can also stop the scan manually. You will find more details on this in SECTION 7.6.

13. You can continue a stopped scan. To do so, select Acquisition > Continue.

Remeasure

14. After the scan you can remeasure the scan points with the status Overrange, Invalidated and Not Measured at a slightly different position. To do so, select Acquisition > Remeasure. If Signal Enhancement is active for at least one channel (refer to SECTION 6.2.7), then in the measurement modes FFT, Zoom-FFT and MultiFrame scan points with the status Valid are also remeasured.

Remeasure File

15. If you have marked single scan points in presentation mode to be remeasured (refer to SECTION 9.1), you can remeasure them. To do so, select Acquisition > Remeasure File. The dialog Open appears. Navigate to the saving location, select the file and click Open.

☞ In addition to that, the software can also remeasure the points automatically, see SECTION 6.2.1 on this.

7.3 Following Scans in the Video Window

In the video window you follow the progress of scans. While scanning, you can see what status the scan points get. You will find a description of the video window in SECTION 2.6.2.

Show and hide scan points

To show and hide the scan points in the video window, click ⊞ or select Scan > Scan Points. To the left of the live video image you can see a legend for the status. There are different views here to select from:

- Scan
- Geometry
- Laser Focus

To change the views, click ⁝⁝ ▾.

Scan Status

Before a scan, all scan points have got the status Not Measured.

If you do not want to scan single scan points, you can assign them the status Disabled. See SECTION 5.4.2 on this.

If you define the scan points, then scan points which are outside the scan area of at least one scanning head are given the status Not Reachable.

If you are working with 3D geometries and parts of the object hides scan points so that they can not reached by at least one laser beam, these scan points are identified as Hidden. A prerequisite for this is that in the dialog Preferences on the page Geometry you have activated Hidden Points Calculation (refer to SECTION 3.4).

When scanning, the software gives every scan point the status Valid, Optimal or Overrange.

The status Optimal can only occur if Signal Enhancement is active for at least one channel (refer toSECTION 6.2.7). At these scan points, the signal-to-noise ratio is relatively high.

At scan points with the status Overrange the input range of the data acquisition board was exceeded on at least one channel.

☞ Please pay attention that the software determines the Scan Status Overrange as well under certain circumstances even though the resulting time signal is displayed unaffected. This is due to the fact that depending on the measurement settings you are working with a higher sample rate as actual be visible in the resulting time signal (Oversampling). If a brief voltage peak causes an overloading, then the scan point get the status Overrange while the decimated time signal is displayed correctly.

If Signal Enhancement is active, scan points can change their status between Valid and Optimal at the end of the scan.

After the scan, you can manually assign the scan points the status Invalidated. You will find details on this in SECTION 9.1.

Geometry Status

If there are no 3D coordinates available, the scan points are given the status No 3D Coordinates. If you are working with a 3D geometry or the distance sensor, you can see whether scan points were measured with the geometry scan unit (status Measured or Optimal Measured) or were calculated with the aid of triangulation of the three laser beams (status Triangulated, only PSV-3D).

☞ Optimal Measured are scan points whose determined signal strength was higher than the threshold value which is given in the dialog Setup Preferences on the page Scanning Head under Signal Level (refer to SECTION 3.3).

Other options are Imported (via ASCII, Universal File or ME'Scope files with the aid of the optional geometry import, refer to SECTION 5.2.8), Interpolated (not or wrongly calculated 3D coordinates have been interpolated from the coordinates of the neighboring scan points) and Modified (the coordinates of the scan points were changed retrospectively).

If the distance measurement has failed, the affected scan points are given the status Failed. If the signal strength of the geometry scan unit being too high or too low is the reason for the measurement failing, then you will see this from the status Too much Light or respectively Too little Light. In all cases this means that these scan points do not have any valid 3D coordinates.

Laser Focus Status

If no focus value has been assigned, the scan points are given the status No Focus. If you have assigned a focus value (refer to SECTION 5.6.1 and SECTION 5.6.2), you will see here if you Assigned Manually, Assigned Fast or Assigned Best the focus value.

If the software has interpolated the focus value of single scan points from those of the neighboring points, these are given the status Interpolated. Scan points for which no focus value could be determined using the method Assign Focus Best are labeled as Failed.

If, in the dialog Preferences on the page Geometry, you have marked the box Calculate Focus Values Automatically, and the selected scan points have 3D coordinates then the software calculates the focus values automatically. These scan points get the status Calculated.

7.4 Using PSV-3D with only One Scanning Head

Thus, you can also use your PSV-3D as a single system with only one scanning head and only one controller (standard PSV with junction box PSV-E-40x-1D), you have to activate it first (refer to SECTION 3.1, PSV-3D as 1D). In the settings, you then have to pay attention to the following:

- The PSV software behaves like with a standard PSV and shows even only one controller and one scanning head in the scanning head control.

☞ Please note that, for this purpose, you can only use the scanning head Top. But it will not be shown as Scanning Head Top in the software.

- The channel allocation does not match the names on the junction box. Please note the following allocation: Vib corresponds to VELO TOP, Ref1 corresponds to VELO LEFT, Ref2 corresponds VELO RIGHT and Ref3 corresponds to REF.

☞ If you want to use the PSV-3D in 1D mode, you have to activate it first. Please read SECTION 3.1, PSV-3D in 1D mode and fault diagnosis in 1D mode on this.

7.5 Messages while Measuring

During a measurement, the status bar and scanning head control can display messages on data acquisition. A list of messages, their causes and information on prevention can be found in TABLE 7.1.

Table 7.1: Messages on data acquisition

Message	Cause	If the message appears permanently	See
OVERRANGE VIB (status bar)	The voltage on the vibrometer channel exceeds the input range set.	Click A/D and display the page Channels. Set the input range on the page Channels to 10V. Then display the page Vibrometer and increase the measurement range for the velocity step by step.	SECTION 6.2.2
☞ The message OVERRANGE VIB can also appear briefly which is caused by noise peaks due to dropouts. In this case, do not reset the input range.			
OVERRANGE REF (status bar)	The voltage on the reference channel exceeds the input range set.	Click A/D, display the page Channels and set the next highest input range of this reference channel.	SECTION 6.2.2
NO TRIGGER (status bar)	Triggering is set but the software can not detect a trigger signal.	Click A/D, display the page Trigger and check the trigger settings. Also check the cabling.	SECTION 6.2.6 and hardware manual
Display OVER is red (scanning head control)	The measurement range for the velocity has been exceeded.	Click A/D, display the page Vibrometer and set the next highest measurement range for the velocity.	SECTION 6.2.8

7.6 Stopping a Measurement

With single shots and with scanning, the software ends data acquisition once the total sample time has expired. You can also stop measurements manually. Continuous measurements have to be stopped manually.

To stop a measurement, click ✋ or select Acquisition > Stop.

Single point measurement

If you stop a single point measurement, the following applies:

- If there are less than three seconds to the end of the sample time, the software carries out the measurement completely and then ends data acquisition.
- If there are more than three seconds to the end of the sample time, the software aborts the measurement. In the measurement modes FFT and Zoom-FFT, you can always display and save the time signal for aborted measurements, but may not be able to save a spectrum. For long sample times, single shot is recommended if you want to evaluate and save spectra.

Scan If you stop a scan, the following applies:

All completely measured scan points are already saved. You can evaluate the scan the same as you can a completed one.

7.7 Test Mode (as an Option)

In the test mode, the software calculates the errors which are caused by the analog components during signal processing. Prior to demodulation, the software corrects these errors using special algorithms. To do this, you need the option VDD.

You have to run test mode after having installed both the option VDD and the hardware, and having set up the software, and then repeat it regularly. In doing so, the following applies:

- If you only want to measure to 10 nanometers accuracy or less, you should run the test mode again every three months.
- If you want to measure more accurately than 10 nanometers or if the ambient temperature has changed by ±5°C or more, repeat the test mode every day.

☞ Test mode can be carried out automatically for the controller OFV-5000 if the controller is controlled remotely via the RS-232-interface. Test mode is then run every time the software is started.

To run the test mode, you will need

- a test object which is vibrating – for example, a loudspeaker. The displacement amplitude should be at least 1 µm.
- a piece of reflective film.

To run test mode, proceed as follows:

1. Switch the PSV or MSA/MSV on and wait for 30 minutes. The components are then in thermal equilibrium.
2. **Only PSV:** Attach a piece of reflective film to the test object and point the scanning head at it.
3. Let the test object vibrate.
4. **Only PSV:** Open the beam shutter on the scanning head, fine-position and focus the laser beam on the reflective film. The signal level display should light up completely.

   Only MSA/MSV: Open the beam shutter on the sensor head, fine-position and focus the laser beam on the test object. The signal level display should light up completely.
5. In the software, select Setup > VDD Test.

☞ If the command is not active, select Setup > Preferences, display the page Devices, and in the list Junction Box select the junction box VDD-Z-01x, VIB-E-400-VDD, MSA-E-500 (VDD) or MSA-E-40x (VDD), refer also to SECTION 3.1.

The software records the vibration and calculates the correction factors for the errors caused by analog components.

Should test mode fail, then first of all check the cabling and the test assembly. If cabling and the test assembly are correct, then it is possible that the displacement amplitude of the test object is too small.

If test mode is successful, you can now start a measurement as described in SECTION 7.1 or SECTION 7.2.

7.8 Example Measurements

Here you will find a few application examples which give you detailed instructions on various measurement tasks.

- Optimizing Input Signals with Signal Enhancement, refer to SECTION 7.8.1
- Controlling External Function Generator (as an Option), refer to SECTION 7.8.2
- Controlling Internal Function Generator (as an Option), refer to SECTION 7.8.3
- Measurement with FastScan (as an Option), refer to SECTION 7.8.4
- MultiFrame Measurement (as an Option), refer to SECTION 7.8.5
- Controlling a Second Vibrometer, refer to SECTION 7.8.6

7.8.1 Optimizing Input Signals with Signal Enhancement and Speckle Tracking

When scanning with Signal Enhancement and Speckle Tracking, you get an approximately even noise level for all scan points.

☞ Speckles occur when laser light is scattered back from optically rough surfaces. The light scattered back from a certain point can cause constructive or destructive interference. Correspondingly, the detector sees a bright or a dark speckle. Dark speckles lead to dropouts in the vibrometer signal. Dropouts increase the noise level significantly.

Principle

Signal Enhancement works as follows:

- In measurement mode FFT, Zoom-FFT or MultiFrame, you suppress dropouts in averaged spectra using Signal Enhancement and Speckle Tracking. In addition, the software evaluates the noise level of the single scan points. You will find more information on this in your theory manual.
- In measurement mode Time with averaging Time, the software uses a median algorithm for averaging with active Signal Enhancement.
- Only for PSV-400-H4 and PSV-400-3D-H in measurement mode Time: If possible, time signals were acquired with a higher sample frequency (input sample frequency) as the one which corresponds to the selected bandwidth or sample frequency (output sample frequency - Oversampling). In the highly sampled time signals, the software searches the spikes caused by dropouts. If the length of these spikes are shorter as the duration for acquiring two samples in the decimated output time signal, then the spike is replaced by an interpolated sample value. The

Oversampling factor must thereby be at least four (Oversampling factor = factor between input sample frequency of the data acquisition board and the selected output sample frequency). This is always the case with bandwidths ≤ 20kHz or sample frequencies ≤ 51.2kHz.

Activate

To activate Signal Enhancement and Speckle Tracking, proceed as follows:

1. Click A/D or select Acquisition > Settings. The dialog Acquisition Settings appears.
2. Display the page SE.
3. On the left you mark the channels which Signal Enhancement is to be active for. You will find information on this in SECTION 6.2.7.
4. If Signal Enhancement is active for the vibrometer channel, then you can activate Speckle Tracking for this channel on the right.
5. Set the parameters on all other pages of the dialog. You will find information on this in SECTION 6.2.
6. Click OK.

You can now start a measurement as described in SECTION 7.1 or SECTION 7.2.

7.8.2 Controlling an External Function Generator (as an Option)

Using the software you can control certain function generators via an IEEE-488/GPIB interface. To do this, you need the option External Signal Generator.

☞ You can set which generator you are using via Setup > Preferences on the page Devices.

The software supports the following function generators:

- HP 33120A
- Agilent 33120A
- Agilent 33250A
- PREMA ARB1000.

To control an external function generator, proceed as follows:

Make a connection

1. Connect your PC to the function generator via an IEEE 488/GPIB or RS-232 interface.
2. Switch the function generator on.
3. Only 33120A: Configure the interface of the function generator as described in its manual. Set HPIB/488 or RS-232 as the interface and as HPIB address 10.
4. Start the software or go into acquisition mode.
5. Select Setup > Preferences and open the page Devices. Here you set the correct connection to the generator (refer also to SECTION 3.1).

6. Click OK. The generator is initialized.

Set the parameters

7. Click A/D or select Acquisition > Settings. The dialog Acquisition Settings appears.
8. Display the page Generator.
9. At the top left, tick the box Active to activate the function generator.
10. Set the parameters for the signal you want to emit. You will find information on this in SECTION 6.2.9.
11. Set the parameters on all other pages of the dialog. You will find information on this in SECTION 6.2.
12. Click OK.

Signal output

13. Start (stop) the signal output of the function generator. To do so, click ∿ or select Acquisition > Generator.

☞ When scanning, the signal output starts automatically.

You can now start a measurement as described in SECTION 7.1 or SECTION 7.2.

7.8.3 Controlling Internal Function Generator (as an Option)

Using the software you can control the internal function generator of the PSV-400, PSV-300, MSA-500, MSA-400, MSV-400 or MSV-300. To do this, you need the option Internal Signal Generator. The output signal of the internal function generator is available at a BNC jack on the junction box (refer to hardware manual).

☞ You can set which generator you are using via Setup > Preferences on the page Devices.

To control the internal function generator, proceed as follows:

Set the parameters

1. Click A/D or select Acquisition > Settings. The dialog Acquisition Settings appears.
2. Display the page Generator.
3. At the top left, tick the box Active to activate the function generator.
4. Set the parameters for the signal you want to emit. You will find information on this in SECTION 6.2.9.
5. Set the parameters on all other pages of the dialog. You will find information on this in SECTION 6.2.
6. Click OK.

Signal output

7. Start (stop) the signal output of the function generator. To do so, click ∿ or select Acquisition > Generator.

☞ When scanning, the signal output starts automatically.

You can now start a measurement as described in SECTION 7.1 or SECTION 7.2.

7.8.4 FastScan (as an Option)

You can fast scan at individual frequencies. To do this, you need the option FastScan. The principle of FastScan is a regression in the time domain.

To carry out a FastScan, proceed as follows:

Set the parameters

1. Click A/D or select Acquisition > Settings. The dialog Acquisition Settings appears.
2. Display the page General and select the measurement mode FastScan. In the dialog a page with parameters for FastScan appears. The pages Frequency, Window and Trigger disappear.
3. Display the page FastScan and set the parameters. You will find information on this in SECTION 6.2.11.
4. Set the parameters on all other pages of the dialog. You will find information on this in SECTION 6.2.
5. Click OK.

Measure

6. You start and stop FastScans the same way as normal scans. See SECTION 7.2, SECTION 7.5 and SECTION 7.6 on this.

☞ With a FastScan there is no leakage. Triggers are not active. If you are controlling a function generator with the software, then a sinusoidal signal with the frequency of the FastScan is used for excitation.

Display data

7. You can display data for FastScans as described in CHAPTER 8, but no spectra.

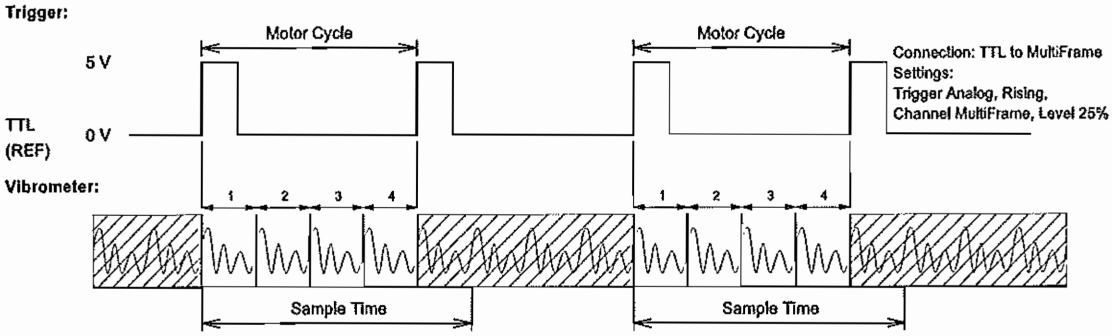
Evaluate

8. You can evaluate FastScans as described in CHAPTER 9, but only at the frequency of the FastScan. You can not define any other frequency bands.

7.8.5 MultiFrame Measurement (as an Option)

Using the software you can divide measurements on combustion engines into frames and analyze the frames individually. To do this, you need the option MultiFrame and a trigger signal (TTL) which determines the start of an engine cycle. For the frame cycle you will need a second trigger signal which determines the end of a frame. You connect this second trigger signal to the channel with the highest number (REF3 or REF24). In the software, the channel will be named MultiFrame.

Motor Cycle (Example: 4 Frames, 1 Pulse per Motor Cycle)



Frame Cycle (Example: 4 Frames, 4 Pulses per Motor Cycle)

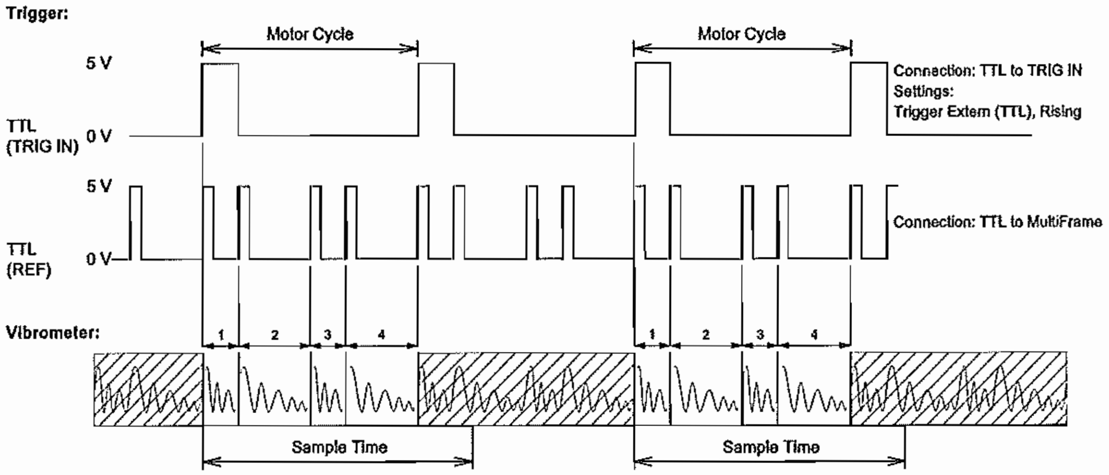


Figure 7.2: Schematic representation of setting frame boundaries

There are three ways of setting the frame boundaries (refer also to SECTION 6.2.13):

- Manually
- Automatically with the aid of the engine cycle
- Automatically with the aid of the frame cycle

Manually

If you manually set the frame boundaries in the analyzer, the start of the engine cycle is determined by a trigger signal at TRIG IN (TTL).

Engine cycle If the frame boundaries are set automatically by the engine cycle, the start and the end of the engine cycle are determined by a trigger signal (TTL, rising edge) at MultiFrame. All frames are the same length.

Frame cycle If the frame boundaries are set automatically by the frame cycle, the start of the engine cycle is determined by a trigger signal (TTL, rising edge) at TRIG IN. A second trigger signal (TTL, rising edge) at MultiFrame ends the frame.

To make a MultiFrame measurement, proceed as follows:

Cabling One way of cabling the system and the necessary settings in the software for this is shown in TABLE 7.2. In principle other versions of cabling would also be possible.

Table 7.2: Example of connecting up the trigger signals for MultiFrame measurements

Determining the frame boundaries	Cabling	Setting in the software
Manually	Trigger signal for the start of the engine cycle: TRIG IN	Source: External (TTL), Rising Pre-trigger: 0%
Engine Cycle	Trigger signal for the start and the end of the engine cycle: MultiFrame	Source: Analog Pre-trigger: 0% Channel: MultiFrame, Rising Source: 25% Pulses per Engine Cycle: 1
Frame Cycle	Trigger signal for the start of the engine cycle: TRIG IN Trigger signal for the end of a frame: MultiFrame	Source: External (TTL), Rising Pre-trigger: 0%

Set the parameters

1. Click A/D or select Acquisition > Settings. The dialog Acquisition Settings appears.
2. Display the page General and select the measurement mode MultiFrame. A page with parameters for the MultiFrame measurement appears in the dialog.
3. Set all other parameters on the page General. You will find information on this in SECTION 6.2.1.
4. Display the page MultiFrame and set the parameters. You will find information on this in SECTION 6.2.13.
5. Display the page Frequency. Set the parameters as described in the next two steps.
6. At the top left, set the bandwidth.
7. At the bottom right, set the number of samples. Above that, the software shows the lower RPM limit RPM_{min} which it can acquire with the bandwidth and number of samples set. Set the number of samples so that the lower RPM limit is 5 to 40% below the RPM the engine is running at.

8. Display the page Window and set the window functions. As a general rule, the window function Tapered Hanning with a parameter of 10 is suitable for MultiFrame measurements. You will find more information on windowing in SECTION 6.2.5 and in your theory manual.

9. Display the page Trigger and set the parameters according to TABLE 7.2.

10. Set 0% pre-trigger.

11. Set the parameters on all other pages of the dialog. You will find information on this in SECTION 6.2.

12. Click OK.

If you set the boundaries of the frames manually, then now follow the steps 13 to 18. If you set the boundaries automatically, you can jump these steps and continue with step 19.

Set frame boundaries manually

13. Start a single point measurement. To do so, click .

14. In the analyzer you will see a MultiFrame toolbar and in the diagram, the boundaries of the frames. In the MultiFrame toolbar, click .

15. Point at a boundary in the diagram. The cursor becomes a ↔.

There are two ways of moving the boundaries:

16. To move a boundary, use the mouse to drag it to the right or left into the required position. You can only move each boundary in a certain range which depends on the neighboring boundaries.

17. To move all boundaries at the same time, press the shift key and drag to the right or left into the required position. All boundaries move at the same time and retain the same respective distances to each other.

18. When you have adjusted all boundaries, click again. Initially the boundaries jump back into their old positions in the analyzer. The new boundaries are not shown until you start a new measurement.

Measure

19. You start and stop MultiFrame measurements as described in SECTION 7.1, SECTION 7.2, SECTION 7.5 and SECTION 7.6.

Display data

20. You can display data for MultiFrame measurements as described in CHAPTER 8.

21. In analyzers you can also display the spectra of the individual frames and the average of all frames. To (de)activate the display of a spectrum, click the corresponding icon in the MultiFrame toolbar.

22. In presentation windows, you can either only display an individual frame or the average respectively. Select the data set you want to display in the list Frame Frame 4 in the legend for the object.

Exporting Universal File or ME'Scope

23. If you export a MultiFrame measurement as a Universal File or in ME'Scope format (refer to SECTION 10.2.3), the software will create an own file for every single frame and for the average.

7.8.6 Controlling a Second Vibrometer

Apart from the PSV, MSA or MSV, you can control a second Polytec vibrometer at the same time. To do this, you need an IEEE488 / GPIB board or a free RS232 interface in your PC.

Supported controllers

You will find an overview of the controllers and interfaces supported as well as information on cabling in TABLE 7.3.

Table 7.3: Supported controllers and interfaces

Vibrometer	IEEE-488/GPIB	RS-232	RS-232 cable
CLV-1000/2000/3000	-	x	Null modem (cross-wired)
CLV-2534	-	x	Null modem (cross-wired)
HLV-1000	-	x	Null modem (cross-wired)
IVS-300	-	x	Special cable
NLV-1232	-	x	Null modem (cross-wired)
NLV-2500	-	x	Null modem (cross-wired)
OFV-2500	-	x	Null modem (cross-wired)
OFV-3000/3001/3001 S	x	x	1:1
OFV-3020/3020 S	x	x	1:1
OFV-3300-1/3300-2	x	x	1:1
OFV-3310/3320	x	x	1:1
OFV-5000	-	x	Null modem (cross-wired)
OFV-5000-S	-	x	Null modem (cross-wired)

Supported commands

The connection supports the following commands:

- Set the parameters of the controller for data acquisition.

Only Vibrometer Controller 1 (refer to SECTION 2.3):

- Query exceeding the measurement range (OVERRANGE).
- Query the optical signal level.
- OFV-5000 with scanning head PSV-I-400: Focus the laser beam automatically (Autofocus).
- OFV-5000 with sensor head OFV-505: Focus the laser beam automatically (Autofocus).
- OFV-5000 with sensor head OFV-551 / -552: Control the beam shutter, dim the laser beam (as an option).
- OFV-3001S with scanning head OFV-056: Focus the laser beam.
- OFV-3001S and OFV-3001 with the sensor head OFV-303: Focus the laser beam.

To control a vibrometer, proceed as follows:

Make a connection

1. Connect the PC to the controller via an IEEE-488/GPIB or RS-232 interface, refer also to TABLE 7.3.

☞ If you are using an RS-232 interface, then set 9600 Baud on the controller, on the OFV-5000 and OFV-2500 controller 115200 Baud.

2. Switch the controller on.

3. Only OFV-3300-1 and OFV-3310: Use the key ↑ on the front panel of the controller to switch its display to the menu SETTINGS. Then you can monitor the current settings on the display.

4. Start the software or go into acquisition mode.

5. Select Setup > Preferences. The dialog Preferences appears.

6. Display the page Devices. Make the necessary settings here (refer also to SECTION 3.1).

7. Display the page Channels.

8. In the column Vibrometer, connect the controller to the digital channel it is providing the signal for. You will find information on this in SECTION 3.2.

9. Click OK. The controller is initialized.

Set the optics

10. If you can not see the scanning head control in the application window, select View > Scanning Head to display it. At the top you can see the optical signal level as a bar.

☞ If you are using the sensor head OFV-551/-552, you can control the beam shutter and use it to turn the laser on and off. To do so, mark the box Laser. Apart from that, as an option, the slider Laser Dimmer is displayed. By moving this slider with the mouse in the direction Max. you can reduce the light intensity of the laser beam.

OFV-505 OFV-551/552

Figure 7.3: Elements of the scanning head control

11. OFV-5000 with scanning head PSV-I-400 or sensor head OFV-505: You can focus the laser beam automatically with the icon AE.

12. OFV-3001S with scanning head OFV-056: You can focus the laser beam using the icons ◀N (close-up) and F▶ (infinity).

Set the parameters

13. Click A/D or select Acquisition > Settings. The dialog Acquisition Settings appears.

14. Display the page Vibrometer.

15. Set the parameters of the controller for data acquisition. You will find information on this in SECTION 6.2.8 and in your vibrometer manual.

16. Set the parameters on all other pages of the dialog. You will find information on this in SECTION 6.2.

17. Click OK.

You can now start a measurement as described in SECTION 7.1 or SECTION 7.2.

8 Displaying Data

You can set up the properties of the data display. See SECTION 8.1 on this.

In the software you work with the following windows to display data:

- In acquisition mode: a **video window**, any number of **analyzers**
- In presentation mode: any number of **presentation windows, analyzers** and **signal processors**

You will find a description of the analyzer in SECTION 2.6.3.

You can work in analyzers. Read SECTION 8.2 on this.

To evaluate the scan, open a presentation window and then set up the window and the view of the measurement object. Read SECTION 8.3 on this.

You can select the data set that is displayed in the analyzer. Read SECTION 8.4 on this.

If you are working with 3D geometries, you can merge several individual scans to a combined file (stitching). Read SECTION 8.5 on this.

Afterwards you can use your measurement data as the basis for further calculations. Read SECTION 8.6 on this.

If you want to add user-defined data sets to 3D geometries, you can create a new scan file for that. Read SECTION 8.7 on this.

8.1 Setting up Display Properties

In the dialog Display Properties, you can select the following settings:

- Setting up the object, refer to SECTION 8.1.1
- Setting up the view style of measurement data, refer to SECTION 8.1.2
- Setting up 3D view, refer to SECTION 8.1.3

To open the dialog, double-click the object or click it with the right mouse button and select General Properties, Data Properties or 3D View Properties in the context menu.

To set up the view style of the measurement data and the 3D view in acquisition mode, you have to change to the 3D View. To do so, in the video window, click **3D**. However, you will then no longer see a live video image but, as in presentation mode, a snapshot of the video image at the time at which you changed the view.

☞ In acquisition mode, you can only switch to 3D View if you have defined scan points.

To set up the 3D view in presentation mode, you have to change to the 3D View. To do so, in the presentation window, click 3D .

☞ In presentation mode, you can only switch to the 3D View if you have selected the view Object, Single Scan Point or Average Spectrum.

8.1.1 Setting up the Object

The contents of this page are different depending on whether you are in acquisition mode or in presentation mode.

If you are in acquisition mode, to open the dialog, you can also activate the video window (to do so click it) and then select Scan > Properties. Then display the page General.

☞ Depending on the type of measurement and the geometry, not all settings options are shown in the dialog.

If you are in presentation mode, to open the dialog, you can also activate the presentation window (to do so click it) and then select Presentation > Properties. Then display the page General.

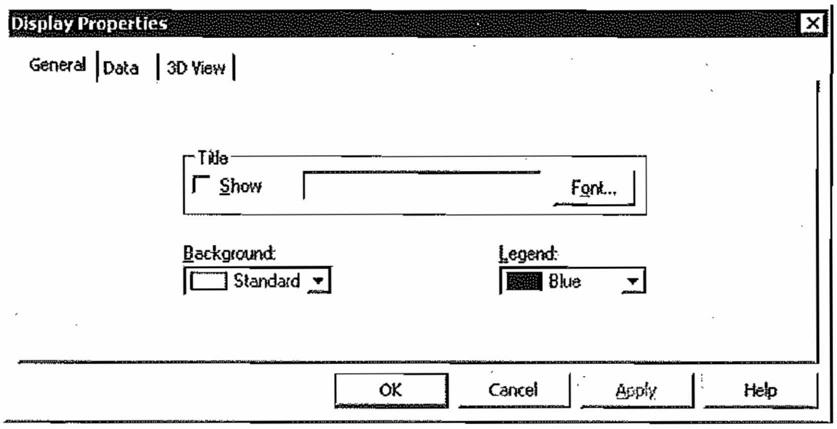


Figure 8.1: Page General

Title At the top you set up the title of the object.

Show: If you would like to display a title over the object, mark the box. You enter the title on the right.

Font: Click here to format the title. The dialog Font appears.

Colors At the bottom you select the background color of the object and the color of the data in the legend (only in presentation mode).

Background: Here you select the background color of the object.

Legend: Here you select the color of the data read in the legend (only in presentation mode).

8.1.2 Setting up View Style of Measurement Data

The contents of this page are different depending on whether you are in acquisition mode or in presentation mode.

If you are in acquisition mode, to open the dialog, you can also activate the video window (to do so click it) and then select Scan > Properties. Then display the page Data.

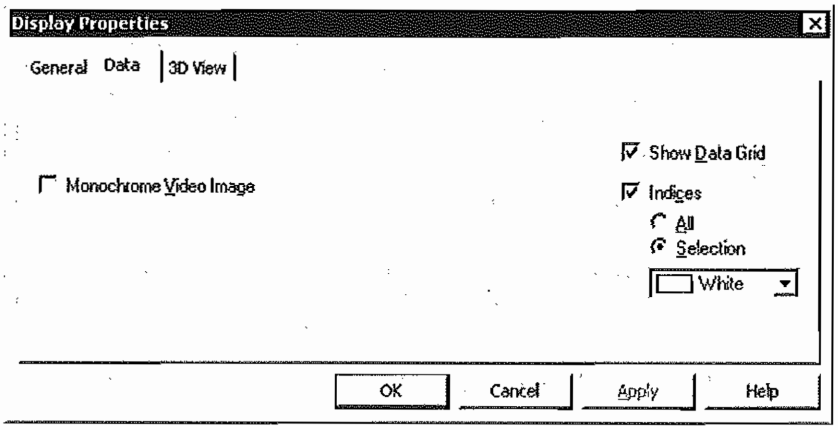


Figure 8.2: Page Data in acquisition mode

Monochrome Video Image: Tick the box if you want the change the video image from color to black and white.

Show Data Grid: Tick the box if you want to see the grid that the scan points are on.

Indices: Tick the box to show the index of scan points. Select whether the indices of all scan points are to be shown or only the indices of selected scan points. In the list below select the color which is to be used to show the indices.

☞ Depending on the type of measurement and the geometry, not all settings options are shown in the dialog.

If you are in presentation mode, to open the dialog, you can also activate the presentation window (to do so click it) and then select Presentation > Properties. Then display the page Data.

☞ New settings on this page with the exception of Scale Z-Range are immediately effective, i.e. without clicking Apply or closing the dialog.

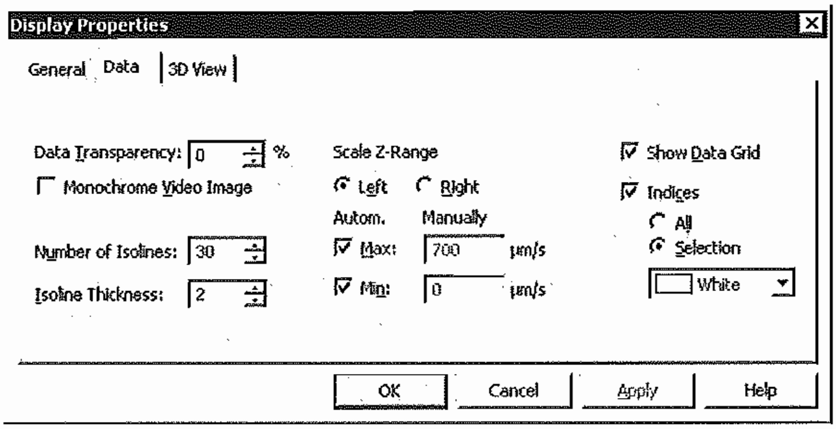


Figure 8.3: Page Data in presentation mode

View style of the measurement data

Data Transparency: Here you enter how transparently the superimposed data is to be shown in the presentation window.

☞ In the view style Wireframe this selection is not active.

Monochrome Video Image: Tick the box if you want the change the video image from color to black and white.

Show Data Grid: Tick the box, if you want to see the grid which the scan points are on in addition to the superimposed measurement data.

☞ In the view style Wireframe this selection is not active.

Indices: Tick the box to show the indices of the scan points. Select whether the indices of all scan points are to be shown or only the indices of selected scan points. In the list below select the color which is to be used to show the indices.

Set up the isolines

Number of Isolines: Here you select how close the isolines are to each other.

Isoline Thickness: Here you select the thickness of the isolines.

Scale Z-Range

Left or **Right:** If you have selected the display type Real&Imag. for example (refer to SECTION 8.4), here you can select which part you want to scale.

Automatically: The software can autoscale maximum and minimum of the z-range individually. To do so, mark the appropriate box Max and Min.

Manually: Through entries in the fields Max and Min you can scale the data manually. To do so, you have to deactivate the corresponding box Automatically. Here you enter the z-range in which the data is to be pictured.

8.1.3 Setting up 3D View

If you are in acquisition mode, to open the dialog, you can also activate the video window (to do so click it) and then select Scan > Properties. Then display the page 3D View.

If you are in presentation mode, to open the dialog, you can also activate the presentation window (to do so click it) and then select Presentation > Properties. Then display the page 3D View.

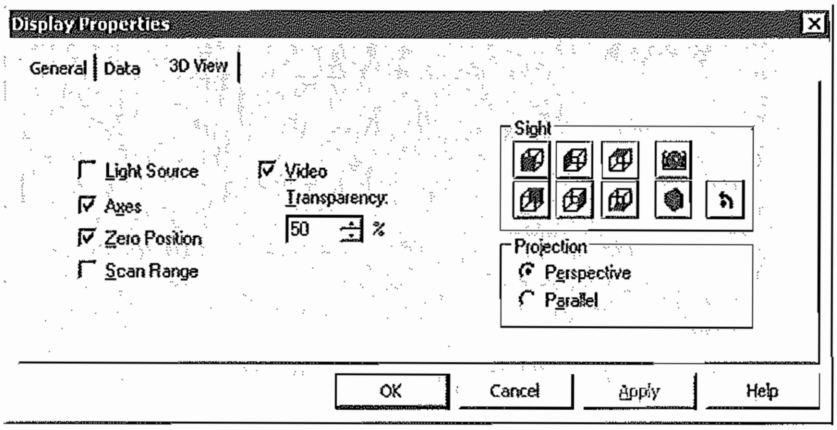


Figure 8.4: Page 3D View

☞ Changes made to the view style or the sight are immediately effective, i.e. without clicking Apply or closing the dialog.

Light Source: Tick the box to switch on the illumination model. It simulates illuminating the object from the direction of the observer.

☞ Depending on the shape of the object, the display of light and shadow may have a detrimental effect on the quality of the presentation. In this case, deactivate the box to switch off the illumination model.

Axes: Tick the box to display a coordinate system top left next to the object.

Zero Position: Tick the box to view the object in its original position in addition to viewing the measurement results.

Scan Range: Tick the box to show lines to help you display the position of the scanning heads in front of the object. In this way you can see whether the 3D alignment has provided a useful result.

☞ You can only show the Scan Range for measurements with 3D geometries (only PSV/PSV-3D). The boxes Scan Range, Video and Transparency are not shown for combined files (refer to SECTION 8.5).

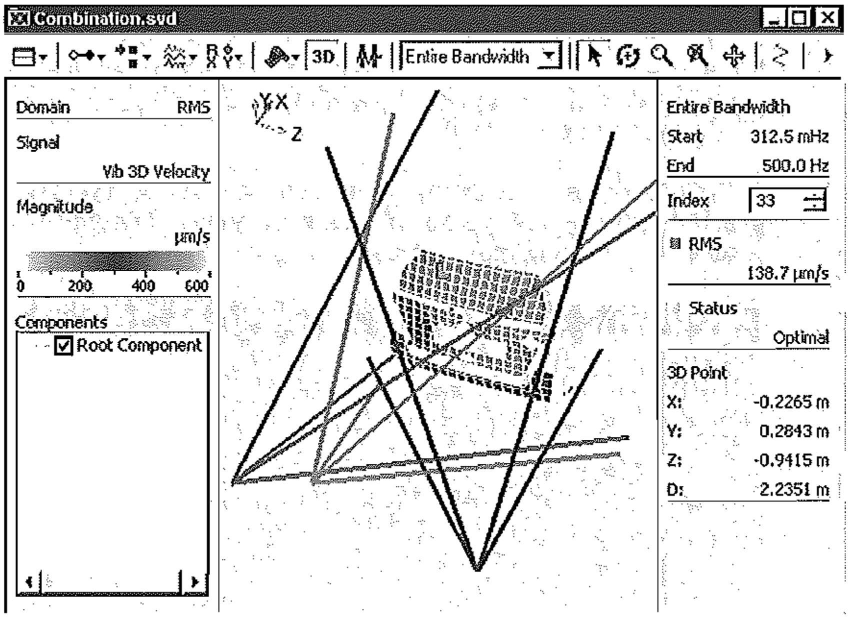


Figure 8.5: Layout of the position of the three scanning heads

Video: Tick the box to show the video image.

☞ For 3D-geometries, the video image is only shown if:

- the 2D alignment is good quality, i.e. the laser beam hits the precise position on the video image,
- for the scan points 3D coordinates are existent and
- at least four scan points have been defined which cover a larger area of the video image.

Transparency: Here you enter how transparently the video image is to be displayed.

Sight

The icons in the field Sight show the line of sight of the object. You can move the object more precisely by clicking these icons than by dragging with the mouse.

Sight on the object from the front

Sight on the object from the back

Sight on the object from the left

Sight on the object from the right

Sight on the object from the above

Sight on the object from the below

Sight of the video camera (only for 3D geometries; for this purpose the same limitations apply as with the display of the video image, see above under Video)

Sight on the object at an angle from front, left and above

Rotating the object around the line of sight

You can show (hide) a coordinate system which shows you the resulting orientation of the object (see above, Axes).

☞ You can also set the line of sight directly in the video window or presentation window using the mouse. To do so, click to select the mode Rotate. Then click the object and using the mouse drag it into the direction you require.

Projection

Here you select the type of projection of the object.

Perspective: The object is shown in perspective, i.e. parts in the front of the image become larger, parts in the background of the picture are shown smaller.

Parallel: All parts of the object are shown the same size regardless of their distance from the observer.

☞ Parallel projection makes it easier to differentiate between in-plane and out-of-plane vibrations. Particularly with out-of-plane vibrations, the perspective layout viewed from the top can give the impression that the object is being stretched and contracted again.

8.2 Working in Analyzers

Analyzers show measurement data and evaluated data in x-y diagrams. You will find a description of the analyzer in SECTION 2.6.3.

You select the data set to be displayed in the analyzer as described in SECTION 8.4.

Analyzers offer user-friendly functions to present data quickly and usefully.

- Zooming in Analyzers, refer to SECTION 8.2.1
- Setting Cursors and Reading Data, refer to SECTION 8.2.3
- Scaling Axes, refer to SECTION 8.2.2.

You will find more functions in the dialog Analyzer Properties.

- Setting up the Presentation of Graphs, refer to SECTION 8.2.4. There you can scale and set line style and color of the graph.
- Setting up Diagrams, refer to SECTION 8.2.5. To do so, select Analyzer > Properties and display the corresponding side. Alternatively, click the analyzer with the right mouse button and select the required function in the context menu.

The analyzer simultaneously shows up to 0.5 mega-samples for time series as standard. If the measurement contains more data, then this is reloaded during scrolling. If you want to see several time values at once, then to do so you can increase the number of time values shown simultaneously as described in SECTION 9.4.2.

☞ The maximum number of time values shown simultaneously can only be increased in presentation mode. In acquisition mode the analyzer always shows only a maximum of 0.5 mega-samples.

8.2.1 Zooming in Analyzers

You can zoom on sections of the diagrams.

Zoom the x- or y-axis

To zoom the x- or y-axis individually, proceed as follows:

1. Point at an edge point of the section required on the axis. The cursor becomes a magnifying glass.
2. Press the mouse button and drag horizontally or vertically to the other edge point.

Scroll the x-axis

The scroll bar below the diagram shows the position of the zoomed section on the whole x-axis range. You can scroll along the x-axis with the current zoom factor. To do so, move the bar in the scroll bar to the right or to the left. You can also click the arrows to the right and left of the scroll bar.

Zoom both x- and y-axis

To zoom both x- and y-axis simultaneously, proceed as follows:

1. Click or select Analyzer > Zoom In.
2. In the diagram, point at a corner of the section required.
3. Press the mouse button and drag to the diagonally opposite corner.

Pan the zoomed section

You can pan the zoomed diagram section. To do so, you have the following options:

1. Using the middle mouse button (mouse wheel), click in the zoomed diagram. Hold the mouse button pressed and pan the diagram section. If you have given the middle button a special function (e.g. double-click), then you will have to proceed as described in step 2.
2. Click or select Analyzer > Pan. You can now pan the diagram section while pressing the left mouse button.

Zoom out

To undo the last zoom action or autoscaling, click or select Analyzer > Zoom Out.

To undo all previous zoom actions, click while holding the shift key pressed. You can also select Analyzer > Zoom Out holding the shift key pressed.

8.2.2 Scaling the Axes

You can scale the y-axis automatically or scale the x- and y-axis manually.

Autoscale the y-axis

When you have started a measurement or are displaying another data set, then the y-axis range is often unsuitable. You can then autoscale, i.e. the software selects the y-axis range displayed corresponding to the y-range of the data. To do so, click or select Analyzer > Auto Scale. To switch Auto Scale off again, click again.

Scale manually In the dialog Analyzer Properties you can scale manually and set further scaling properties. To open the dialog, point at an axis (the cursor becomes a magnifying glass) and double-click. You can also activate the analyzer (to do so, click it), select Analyzer > Properties and then display the page Ranges.

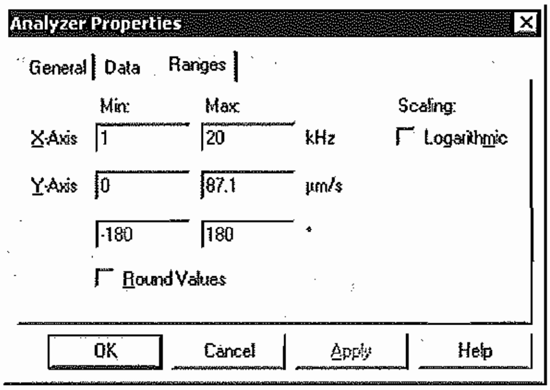


Figure 8.6: Page Ranges

Max and **Min:** Here you enter the x- and y-axis ranges you want to display.

☞ If you want to display two diagrams (e.g. Mag.&Phase), here you can define the y-axis ranges respectively.

Scaling: This box only appears if the active analyzer is displaying a spectrum. Here you select logarithmic or linear scaling of the x-axis.

Round Values: Here you select whether the axis values displayed should be round. The software then rounds the values in Min and Max to be suitable. Round Values is also active when zooming. The zoomed section is then usually slightly larger than selected.

8.2.3 Setting Cursors and Reading Data

In the analyzer you can set cursors to read individual data points. Cursors are represented by thin vertical lines. In display type Nyquist you can not set any cursors. You will find details on how to animate time data in SECTION 9.4.2.

Single cursor To set a single cursor, proceed as follows:

1. Click or select Analyzer > Cursor.
2. Click in a diagram.

Read data You can see the cursor's coordinates in the legend. If the legend is not visible on the right in the analyzer, select Analyzer > Legend to display it.

Cursor properties

In the cursor properties you can set what is to be shown in the legend or the diagram. To show the cursor properties, click or select Analyzer > Cursor Properties. The dialog Cursor Properties appears.

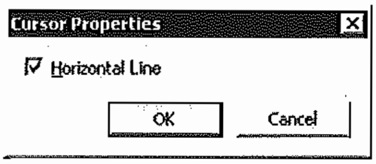


Figure 8.7: Dialog Cursor Properties

Here you can also choose to have a horizontal line displayed at the cursor position in the diagram.

Differential cursor

You can set two cursors and read the difference between coordinates. To do so, proceed as follows:

1. Click or select Analyzer > Differential Cursor.
2. In the diagram, point at the first point you require.
3. Press the mouse button and then drag to the right or left to the second point. The difference between the coordinates also appears in the legend.
4. To show the cursor properties, click or select Analyzer > Cursor Properties. The dialog Differential Cursor Properties appears.

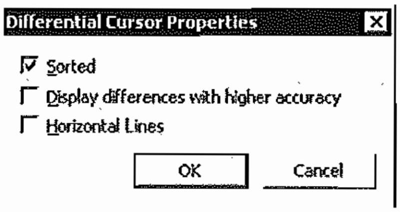


Figure 8.8: Dialog Differential Cursor Properties

5. Here you select the required additional properties.

Band cursor

You can set a band cursor and read different data from the marked area such as the RMS value, the minimum and maximum, the average and the standard deviation. Apart from that, the software can adjust the frequency response function of a one-dimensional oscillator and calculate both the peak position and the attenuation. To do so, proceed as follows:

1. Click or select Analyzer > Band Cursor.
2. In the diagram, point at the first point you require.
3. Press the mouse button and then drag to the right or left to the second point. The data you selected in the Cursor Properties will appear in the legend or the diagram.

4. To show the cursor properties, click or select Analyzer > Cursor Properties. The dialog Band Cursor Properties appears.

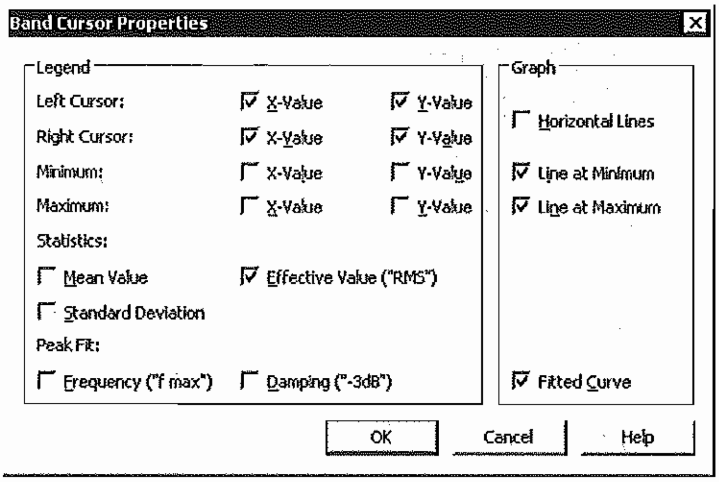


Figure 8.9: Dialog Band Cursor Properties

5. Here you select the required additional data in the legend or displays in the diagram.

☞ The peak fit is only available for spectra.

Harmonic cursor

You can set a harmonic cursor and thus display up to 12 cursor lines of the 2nd, 3rd, 4th etc. order of the fundamental frequency. To do so, proceed as follows:

1. Click or select Analyzer > Harmonic Cursor.

2. In the diagram click the required frequency. In diagram the selected number of cursor lines appears.

3. To show the cursor properties, click or select Analyzer > Cursor Properties. The dialog Harmonic Cursor Properties appears.

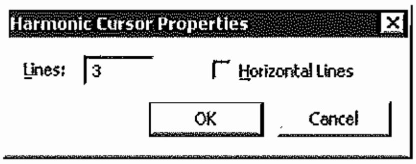


Figure 8.10: Dialog Harmonic Cursor Properties

4. Select the required number of lines and whether corresponding horizontal lines are to be shown.

Move the cursor You can move a cursor to the right or left. To do this, proceed as follows:

1. Point at the cursor. The mouse cursor becomes a ↔.
2. Press the mouse button and then drag to the right or left to the required point. The data in the legend is updated simultaneously.

You can also move a single cursor using the keys → and ←.

Delete the cursor To delete cursors you have set, click , , or again.

Copy cursor values You can copy the values of the cursor currently set via the clipboard in a text file. To do so, proceed as follows:

1. Set the required cursor, differential cursor, band cursor or harmonic cursor.
2. Click the diagram with the right mouse button and select Copy Cursor Values in the context menu.
3. For example, you can now open a text editor and paste the cursor values there from the clipboard.

8.2.4 Setting up the Presentation of Graphs

You set up the presentation of the graphs in the dialog Analyzer Properties. To open the dialog, point at a diagram and double-click. You can also activate the analyzer (to do so, click it), select Analyzer > Properties and then display the page Data.

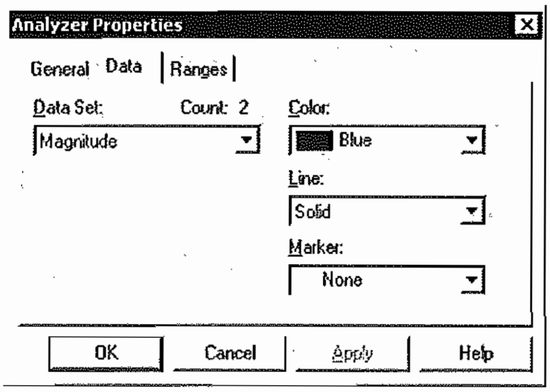


Figure 8.11: Page Data

Data Set: If the analyzer is displaying several diagrams – for example, magnitude and phase – then this is where you select the data set for which you want to set up the presentation.

☞ If you want to display the spectrum of several frames, here you can also select the respective frame (e.g. 1, 2, 3 etc.) and set up its presentation.

Color: Here you select the color of the graph.

Line and **Marker:** Here you select the view style of the graph and, if applicable, the marker. In the view styles Marker, Histogram, Thin bars and Thick bars, only measured y-values are displayed. In the other view styles, the software interpolates between the measured values.

8.2.5 Setting up Diagrams

You set up the look of the diagrams in the dialog Analyzer Properties. The current settings in the dialog are also valid for all analyzers you now open. To open the dialog, double-click an axis name. You can also activate the analyzer (to do so, click it), select Analyzer > Properties and then display the page General.

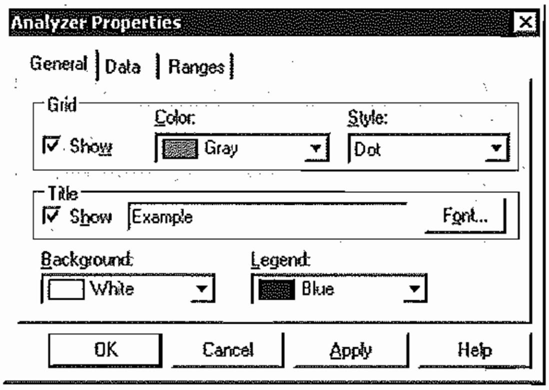


Figure 8.12: Page General

Grid

At the top you set up the grid.

Show: Tick the box to display a grid in the diagram.

Color and **Style:** Here you select the color and line style of the grid.

Title

In the middle you set up the diagram title.

Show: If you would like to display a title over the diagram, tick the box. You enter the title on the right.

Font: Click here to format the title. The dialog Font appears.

Colors

At the bottom you set up the background color of the diagram and the color of the data in the legend.

Background: Here you select the background color of the diagram.

Legend: Here you select the color of the data read in the legend.

8.3 Working in Presentation Windows

You analyze scans in presentation windows. You will find a description of the presentation window in SECTION 2.6.5.

Depending on which functions you are working with in the presentation window, you display it in different views:

- Setting up the View of the Presentation Window, refer to SECTION 8.3.1
- Selecting the View Style of the Data, refer to SECTION 8.3.2
- Setting up Display Properties, refer to SECTION 8.1. You will find more presentation options in the dialog Display Properties. You can scale there and set up the appearance of different views.

The presentation window offers user-friendly functions to present data quickly and usefully.

- Zooming in Presentation Windows, refer to SECTION 8.3.3
- Setting Cursors and Reading Data, refer to SECTION 8.3.4
- Selecting the Color Palette, refer to SECTION 8.3.5

You can select the data set that is displayed in the presentation window. Read SECTION 8.4 on this.

Apart from the display functions, in the presentation window you also have possibilities to evaluate the measurement data. Read CHAPTER 9 on this.

8.3.1 Setting up the View of the Presentation Window

Depending on which functions you are working with in the presentation window, you display it in one of four different views:

- Object
- Single Scan Point
- Average Spectrum
- Profile.

☞ For animations, you can display single vibrational directions (X, Y, Z) and scale the degree of deflection. See SECTION 9.4 on this.

To set the view of the presentation window, click ⊟▾ and select the view required in the context menu. You can also select Presentation > View and then the required view. In the view Object, you will see the data superimposed on the video image, refer also to SECTION 8.3.2. In the other three views you see the presentation window divided horizontally: at the top the view Object and at the bottom an analyzer. You work in the analyzer as described in SECTION 8.2.

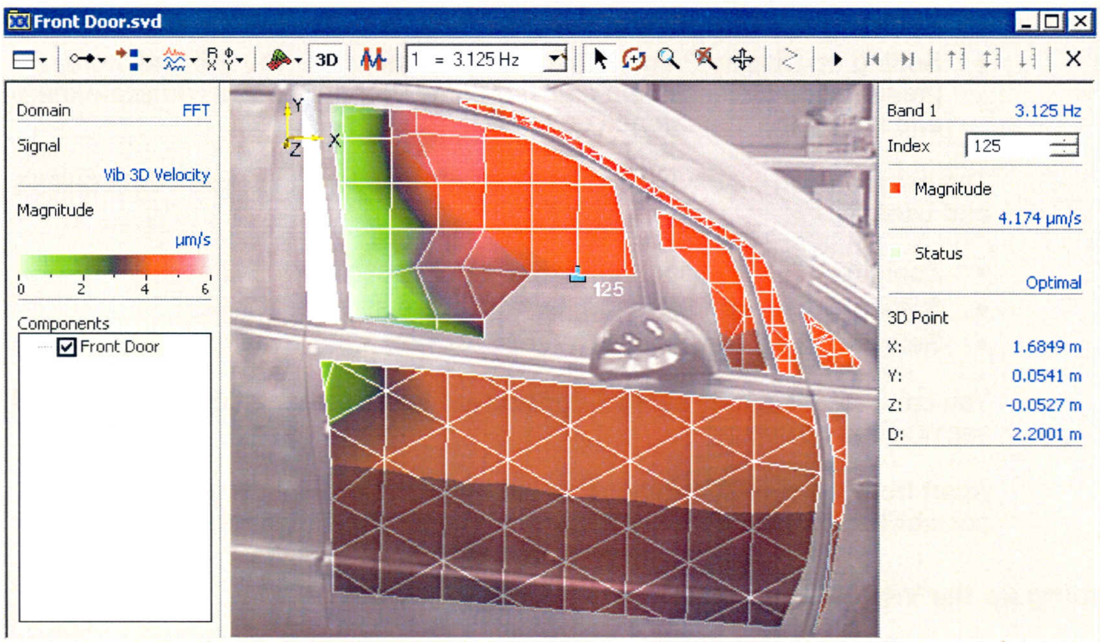


Figure 8.13: Presentation window in the view Object (3D)

Object

You will see the data superimposed on the video image. You can present the data itself in different ways, see SECTION 8.3.2 on this. You can set up the look of the object and the video image (background color, title, transparency etc.) as described in SECTION 8.1.1.

Single Scan Point

In the upper part of the presentation window you see the object. At the bottom you see an analyzer. The analyzer displays the spectrum at the single scan points. At the top, you select the scan point for which the spectrum is shown. To do so, set a cursor at this scan point as described in SECTION 8.3.4.

Average Spectrum

At the top you see the object. At the bottom the analyzer displays the average spectrum of all scan points. The average spectrum is calculated from the amplitude spectra of the valid scan points. See also SECTION 9.1 on this.

Profile

At the top you see the object. You can draw profile sections on the object as described in SECTION 9.3. You will see the profiles at the bottom in the analyzer.

☞ You can not draw any profile sections in the 3D view.

8.3.2 Selecting the View Style of the Data

In the presentation window you see the data superimposed on the video image. You can present the data in different ways:

- Surface
- Wireframe
- Isolines
- Scan Points
- Status Points

In all view styles you can change between the 2D and the 3D view. To do so, click 3D. In all view styles apart from Status Points you will see the data color-coded. You can select the color palette for this as described in SECTION 8.3.5. To the left of the object you can show (hide) a gauge for color-coding. To do so, select Presentation > Gauge.

To select the view style of the data, click and select the view style required in the context menu. You can also select Presentation > View Style and then the required view style.

You can display the live video image outside the scan points.

Surface The software interpolates between the scan points.

Wireframe You will see the connecting lines between the scan points as a color-coded grid.

Isolines You will see equal data values connected with color-coded isolines. You can set up the presentation of the isolines (number, thickness) as described in SECTION 8.1.2.

Scan Points You see each scan point as a color-coded marker which corresponds to its data. In addition to that, you can display the index of each scan point. See SECTION 8.1.2 on this.

Status Points You see the scan points as markers in different colors. The color shows the status of the scan point. See also SECTION 7.3 on this.

3D View You can set up the 3D view style (projection, colors, size) as described in SECTION 8.1.3. You can set the line of sight directly in the presentation window using the mouse. To do so, click . The mouse cursor becomes a . Drag in the direction you require.

3D Geometry You will find detailed information on the presentation of 3D geometries in your theory manual.

Read SECTION 4.5.3 to see how to convert 2D geometry into 3D geometry.

8.3.3 Zooming in Presentation Windows

To zoom in a presentation window, proceed as described in SECTION 2.6.8.

8.3.4 Setting Cursors and Reading Data

If you would like to read data at single scan points, you can set a cursor on the object. You see the cursor as a blue marker. In the view Profile you can not set a cursor.

Set a cursor

To set a cursor, proceed as follows:

1. Display the Object or Single Scan Point view. To do so, click ▭▾ and select Object or Single Scan Point.

2. Display any view style. To do so, click ▾ and select the view style in the context menu. You can select scan points in both the surface view and also the 3D view.

Select scan point

3. Point at a scan point and click. The scan point is shown as a blue marker.

Read data

In the legend you can see the data of the scan point which the cursor is at. If the legend is not visible on the right of the object, select Presentation > Legend to display it.

In the view Single Scan Point you wills see the spectrum at this scan point at the bottom in the analyzer.

Move the cursor

You can move the cursor to other scan points using the mouse. The data in the legend is updated simultaneously. In the view Object you can move the cursor within a joined area using the arrow keys as well.

☞ You can zoom in on the view to be able to see details more clearly. Read SECTION 2.6.8 on this.

Delete the cursor

To delete the cursor or to clear selection, in the toolbar of the presentation window, click .

8.3.5 Selecting the Color Palette

You can choose between different color palettes for color-coding in the presentation window. To do this, proceed as follows:

1. Click or select Setup > Color Palette. The dialog Color Palette Selection appears.

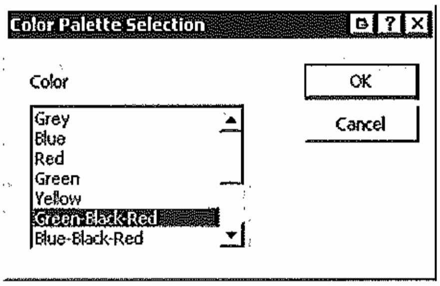


Figure 8.14: Dialog Color Palette Selection

2. Click the color palette required. The color palette Green-Black-Red is set as default.
3. Click OK.

   Or:

   With the right mouse button, click the gauge on the left in the presentation window and select the required color palette from the list.

8.4 Selecting the Data Set Displayed

To display a certain data set, select in the following order:

1. Time signal or type of spectrum
2. Channel or combination of channels
3. Signal or function
4. Display type in which the signal or function is shown
5. 0dB reference
6. Only in presentation windows of data you have captured in FFT mode: Frequency band.

The selection depends on

- the measurement mode,
- averaging, trigger and reference signal; see your theory manual on this as well,
- which displays have already been selected – for example, you can only display a frequency response for frequency spectra and a combination of channels.

☞ With the PSV-3D you can also select the channels Vib 3D or Vib X, Vib Y and Vib Z and also combinations of channels such as Vib X & Ref1.

First of all you have to define frequency bands. Read SECTION 9.2 on this.

If an analyzer is part of a presentation window (refer to SECTION 8.3.1), select the data set shown in the presentation window. If possible, the analyzer displays the same data set.

To display a certain data set, proceed as follows:

Domain

1. Click or select Analyzer > Domain or Presentation > Domain.
2. Select the time signal, a spectrum or the RMS signal in the context menu.

☞ Measurement modes FFT, Zoom-FFT and MultiFrame: To calculate and display a frequency spectrum, the software needs to acquire a complete sampling time. Therefore, during a continuous measurement, the **spectrum** of the **last complete measurement** is displayed at the same time as the **time signal** of the **current measurement**.

Channel

3. Click or select Analyzer > Channel or Presentation > Channel.
4. Select a channel or a combination of channels in the context menu. If you want to use user defined data sets, select the channel Usr, Usr X, Usr Y, Usr Z or Usr 3D. You will find more information on this in the manual on Polytec File Access as well.

Signal

5. Click or select Analyzer > Signal or Presentation > Signal.
6. Select a signal or a function in the context menu. The abbreviations used are explained in TABLE 8.1.

Table 8.1: Abbreviations for functions

Abbreviation	Function
AP	Autopower
CP	Crosspower
FRF	Frequency Response Function
H1	Frequency Response Function
H2	Frequency Response Function
PSD[1]	Power Spectral Density
ESD[1]	Energy Spectral Density
Principal Inputs	Principal Component Analysis (MIMO)

[1] The PSD and ESD signals are only available in the analyzer.

☞ If you have more than 24 signals available (channel Usr), select Signal > More Signals. The dialog Signals appears. Then select the signal required and click OK.

Display type

7. Click [icon] or select Analyzer > Display Type or Presentation > Display Type.

8. Select the way in which the vibration is shown in the context menu.

☞ In the display type Magnitude[dB(A)], the magnitude measured is frequency-weighted according to the standard EN 60651 (IEC 651) (A-weighting). The A-weighting approximately describes the acoustic sensitivity of a human at low magnitudes. The following figure shows the frequency-weighting curve. Outside the range shown, the software weights as follows: Below 10.0 Hz at -70.4 dB and above 20000 Hz at -9.3 dB.

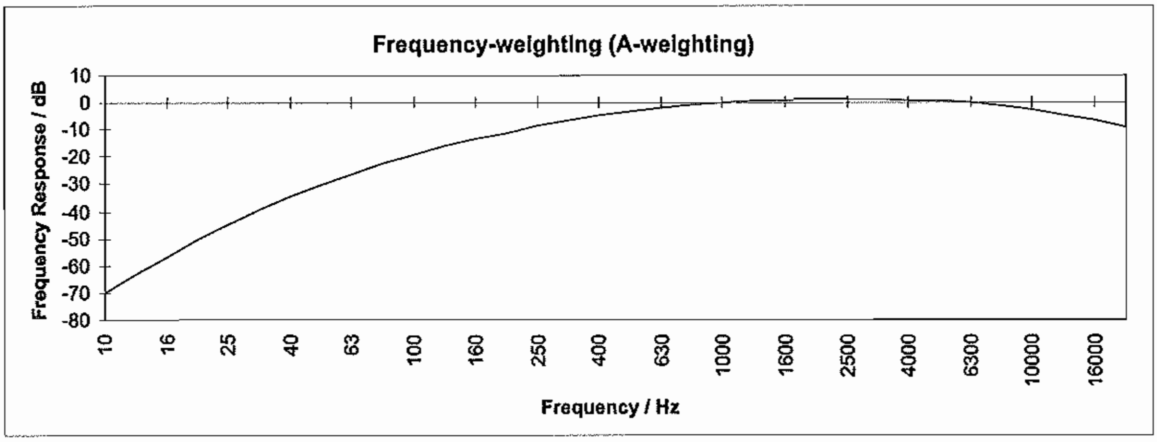


Figure 8.15: Frequency-weighting curve for the display type Magnitude [dB(A)]

☞ In the display type Nyquist, the real part of the magnitude is plotted over the x-axis and the imaginary part over the y-axis. You can limit the frequency range of the display type Nyquist by first of all zooming the x-axis in another display type so that the desired frequency range is displayed and then changing to the display type Nyquist.

0 dB Reference

9. Select Setup > Preferences and display the page dB Reference.

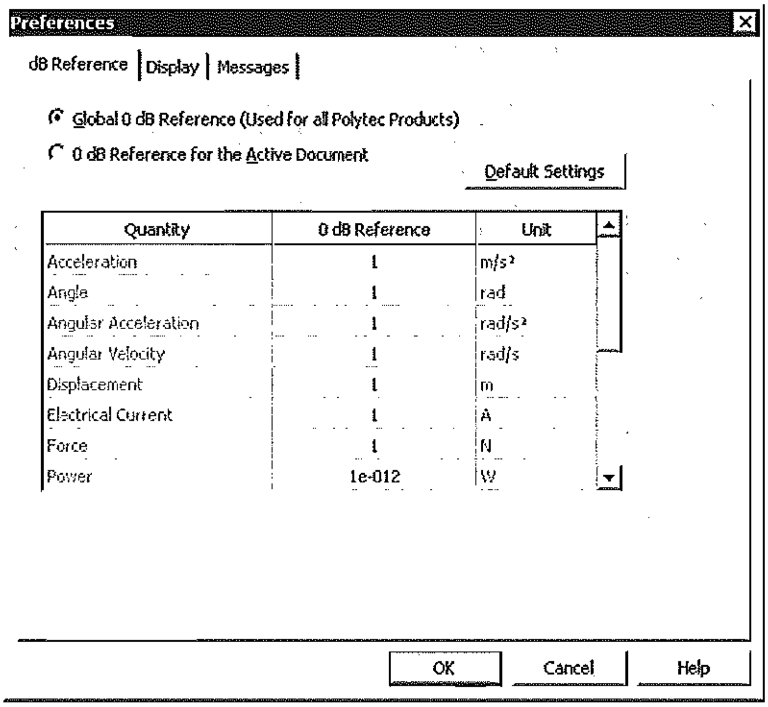


Figure 8.16: Page dB Reference

10. If the settings are to apply to all the Polytec software installed in the PC, mark Global 0dB reference (used for all Polytec products).

    If the settings are only to apply to the file which is currently open, mark 0dB reference for the active document.

The column Quantity shows the available physical quantities, the column Unit the respective applicable unit (ISO).

11. In the column 0dB Reference you define the factor for the respective unit.

☞ Depending on the size of the opened file, it can take quite a while for the new value to be applied!

Example:

Quantity	0dB Reference	Unit
Displacement	2e-3	m

The 0dB reference for the quantity Displacement is 2mm.

12. If you want to evaluate combined signals (e.g. Vib & Ref1), define the 0dB reference for both quantities. The software then automatically determines the 0dB reference of the combined signals.

☞ If you want to recover the original settings for the 0dB reference, click Default Settings.

Frequency band (only in presentation windows)

You have three different ways of selecting the frequency band displayed:

13. Select the frequency band in the toolbar of the presentation window in the list [1 = 1.200 kHz]. If no frequency bands are defined, then the only entry in the list is Entire Bandwidth.

or

Press the key Pg Dn or Pg Up. You will see the next or previous frequency band.

or

Either display the view Single Scan Point or the average spectrum. To do so, click and select Single Scan Point or Average Spectrum.

14. In the toolbar of the analyzer, click . You see the frequency bands in the analyzer in color.

15. Click the required frequency band in the analyzer. The software shows this frequency band at the top.

In TABLE 8.2 you will find a summary of how to select domain, channel, signal and display type.

Table 8.2: Selecting the data set displayed

Click	Or select Analyzer > or Presentation >	Display of	Example
1.	Domain	Time signal, spectrum or RMS signal	FFT, 1/3 Octave RMS Time
2.	Channel	Channel or combination of channels	Vib, Vib3D Ref1, Ref2, Ref3 References (MIMO) Vib&Ref1, Vib&Ref2, Vib&Ref3, Vib3D&Ref1 Ref1&Ref2, Ref1&Ref3, etc.
3.	Signal	Signal or function	Displacement Velocity Voltage Acceleration FRF Displacement/Voltage AP Displacement^2 AP Velocity^2 AP Acceleration^2 Multiple Coherence (MIMO) Virtual Coherences (MIMO) Principal Inputs Voltage^2 (MIMO) PSD Displacement^2/Frequency[1] PSD Velocity^2/Frequency PSD Acceleration^2/Frequency ESD Displacement^2 * Time/Frequency ESD Time * Velocity^2/Frequency ESD Time * Acceleration^2/Frequency
4.	Display type	Way in which the signal or function is shown	Magnitude Magnitude[dB], Magnitude[dB(A)] Mag.&Phase, Mag.[dB]&Phase Phase Real Imaginary Real&Imag. Instant Value Nyquist

[1] The PSD and ESD signals are only available in the analyzer.

You can also evaluate the spectrum with a single cursor. Read SECTION 9.2.1 on this.

8.5 Generating Combined 3D Files (Stitching)

If you are using PSV-3D, you can merge individual measurements with 3D geometries and 3D vibration data to form combined files. This also works with PSV-1D with 3D-geometries, which have either been imported or determined using a geometry scan. For this, the following conditions have to be met:

- The individual measurements must have been made with PSV-3D, or with PSV-1D combined with 3D geometries which were either imported or determined via a geometry scan.
- The coordinate systems of all individual measurements must have the same origin and the same orientation. This means that for 3D alignment the same coordinate system must have been used for the alignment points of all files.
- All individual measurements must have been made using the same basic settings. These include the number of channels, the definition of the reference channel, units, averaging mode and trigger settings as well as the setting for the optional Principal Component Analysis (MIMO).
- However you can select different vibrometer settings, generator signals, input ranges, vibrational directions of the channels and calibration factors.

☞ If you are combining measurements with different vibrometer settings, please make sure that the possible different time delays are only corrected under the following conditions:
- as of OFV-5000 with firmware version 2.0:
- as of PSV 8.3
- acquisition of measurement data in the spectral range (FFT)

No correction is made in the time domain!

- The indices of the scan points may not appear twice. Read more on this under Change Indices in SECTION 5.4.2.

  Exception: identical scan points which are included in several individual measurements and have the same indices in every individual measurement.

☞ You can **not** combine 1D vibration data with different vibrational directions which are existent for scan points with the same indices to 3D vibration data.

You can also generate a new combined filed from several combined files. In doing so, proceed in the same way as when merging individual measurements. In the following section you will find information on:

- Merging Individual Measurements, refer to SECTION 8.5.1
- Working with Combined Files, refer to SECTION 8.5.2

8.5.1 Merging Individual Measurements

To merge several individual measurements to a combined file, proceed as follows:

1. Select File > New > Combined File. The dialog Create Combined File appears.

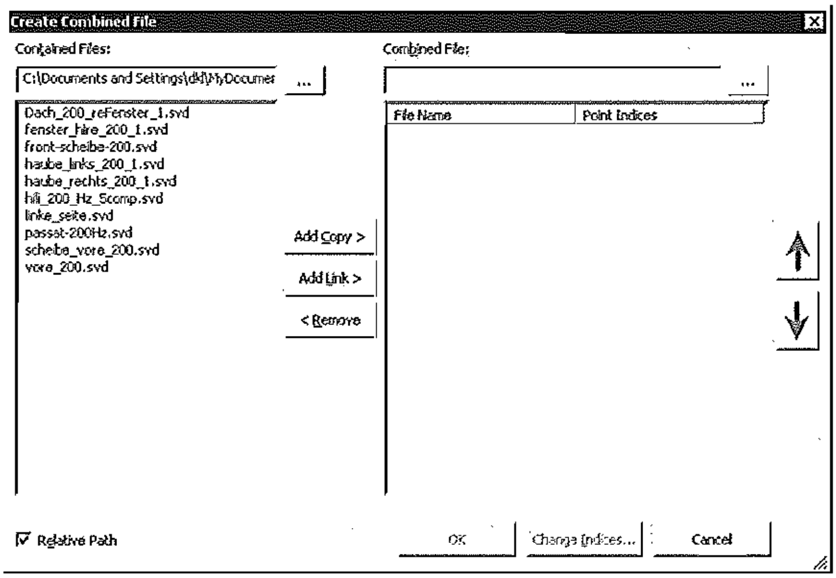


Figure 8.17: Dialog Create Combined File

Add individual measurements

2. Click ... next to the field Contained Files. The dialog Browse For Folder appears.

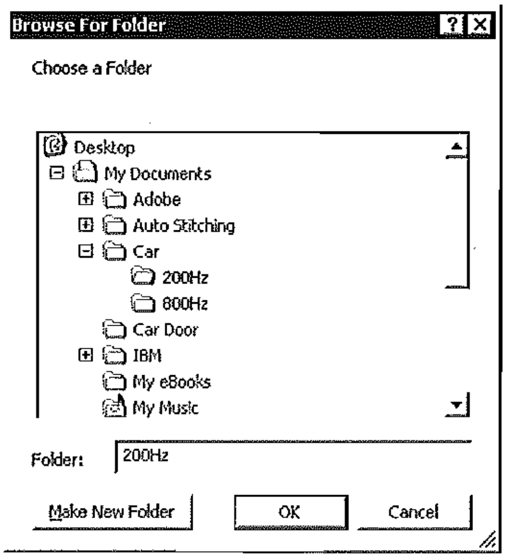


Figure 8.18: Dialog Browse For Folder

3. Navigate in the directory containing the individual measurements you want to merge and click OK.

4. Mark the individual measurements you would like to merge. To select several individual files at the same time, hold the control key pressed and mark the files using the mouse. To select several consecutive files at the same time, hold the shift key pressed and mark the first and the last of these measurements with the mouse.

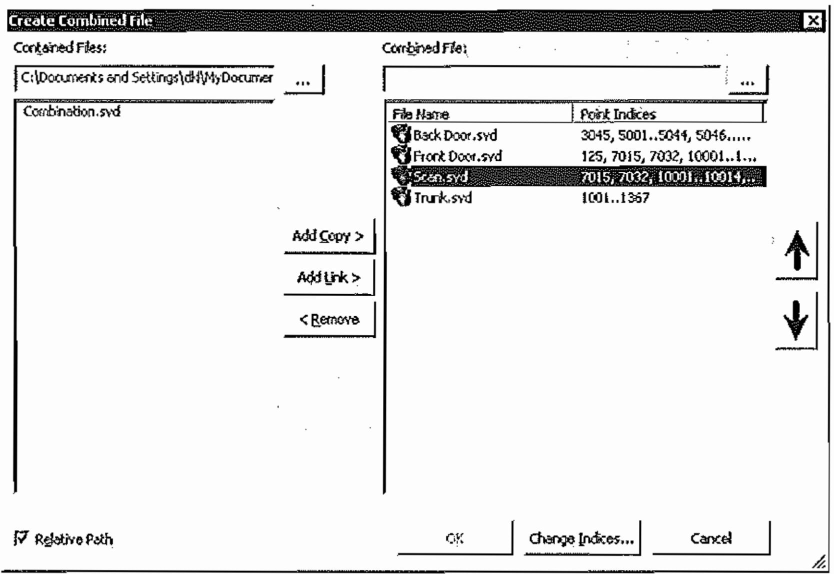


Figure 8.19: Dialog Create Combined File

☞ In the column Point Indices the indices of the scan points of all individual files are displayed. Possible overlaps are marked in red. You can change the indices directly in this dialog. To do so, click Change Indices. The dialog Change Indices appears (refer also to SECTION 5.4.2).

5. Click Copy if you want to include the selected files in the combined file.

Or:

Click Link if you want to link the selected files to the combined file.

☞ If you only link individual measurements, then retrospective changes to these measurements will have an effect on the combined file!

6. Tick the box Relative Path if for linked files only the position in the file system relative to the combined file is to be saved. In this case the links also remain valid if you copy the combined file with the linked files e.g. into another directory and thereby retain the relative folder structure.

7. Click ··· next to the field Combined File. The dialog Save As appears.

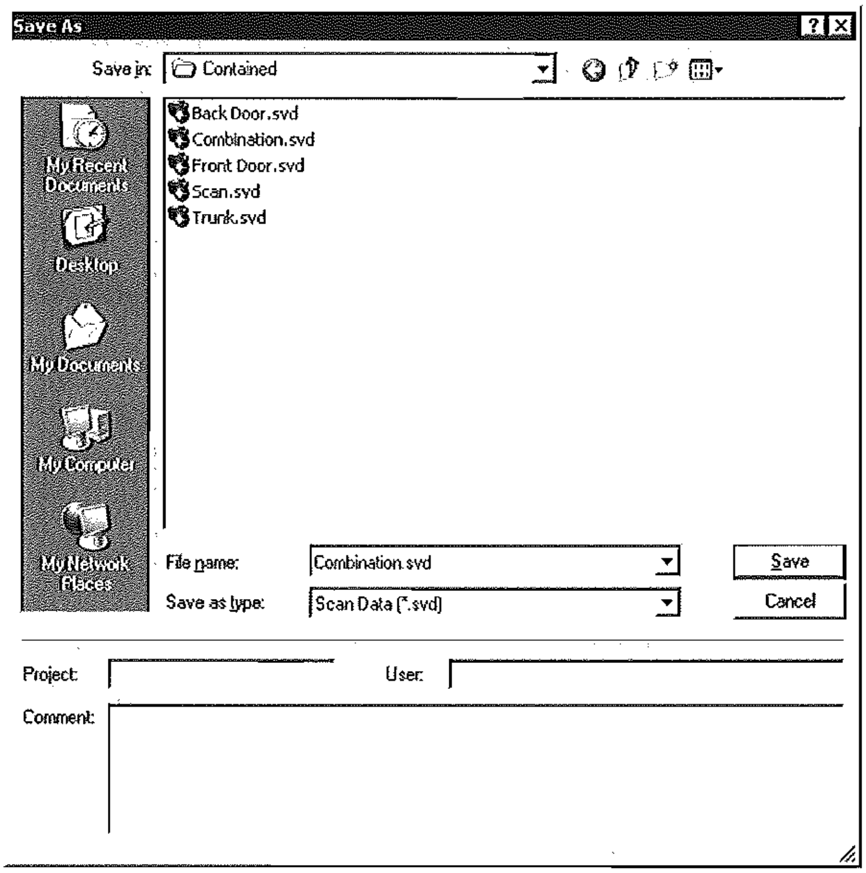


Figure 8.20: Dialog Save As

8. Navigate to the directory in which you want to save the combined file and enter the file name.

☞ If you have the project browser displayed (refer to SECTION 2.6.4), you will then automatically be shown the directory marked there as saving location.

9. Click Save.

☞ If you defined geometry components in the individual measurements (refer to SECTION 5.4.3), then they will be shown in the combined file with the respective hierarchy.

Remove individual measurements

10. To remove files from the list of individual measurements for the combined file, mark them as described in step 4 and click Remove.

11. Click OK.

8.5.2 Working with Combined Files

The same functions are available to you for combined files as they are for individual measurements. All other operations after merging will however only be saved in the combined file. The individual measurements remain unaffected by this.

As a general rule, every change to a file is marked with an asterisk (*) in the file name as soon as you make the change. An exception to this are the frequency bands which are immediately saved after being recalculated. Also the changes that result of you invalidate scan points are saved immediately.

Display combined file

To open the combined file, double-click the file name in the project browser or click it with the right mouse button and select Open in the context menu.

In the 3D view you can simultaneously see the geometry and the vibration data from all parts of the object that you scanned in the individual measurements in three dimensions. Between the geometry parts, you will only see connecting lines if the scan points which are involved have identical coordinates. This is for example the case if you make each of your individual measurements on the same complete geometry.

In the 2D view you can see the geometry and the vibration data of the individual measurements. To show the individual measurements consecutively, select them in the list Contained File.

If you have defined geometry components in the individual measurements, you will see these in the list Components. You can edit the geometry components as described in SECTION 5.4.3.

☞ To draw a profile section (refer to SECTION 9.3) you have to select 2D view.

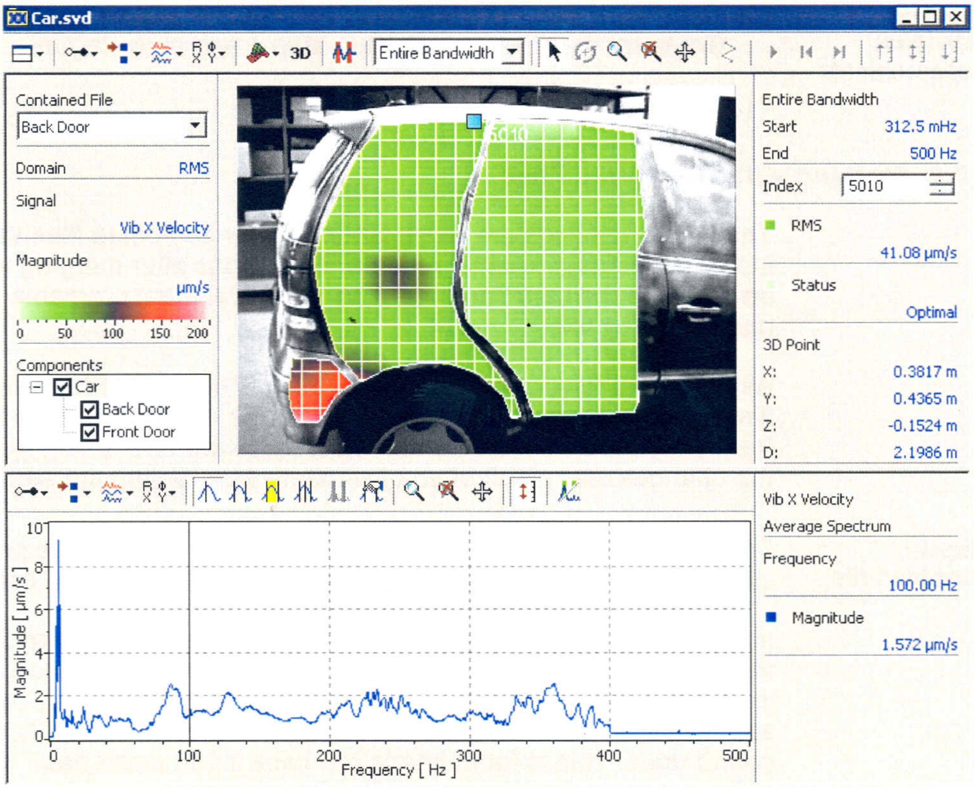


Figure 8.21: 2D view of an individual measurement from the combined file

In the project browser your can see the individual measurements as well as the settings with which these measurements were made. To do so, click the plus sign (⊞) in front of the name of the combined file or in front of the name of the individual measurements.

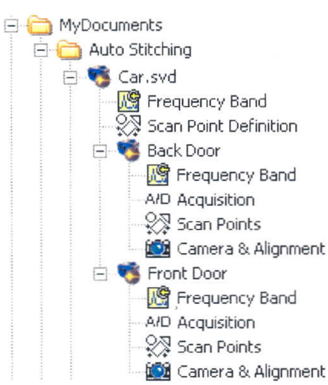


Figure 8.22: Combined file, individual measurements and settings

☞ You can load the scan point definition of the combined file directly from the project browser. The scan point definition of a combined file, however, does not contain the positions of the scan points on the video image. During loading the scan point definition, these positions will be recalculated based on the currently valid 2D alignment.

Overlap of individual measurements

Depending of how you defined the scan areas of the individual measurements, parts of the combined file in the 3D view can overlap.

If the combined file contains scan points twice which have the same indices, the software prioritizes the data according to the order of the individual measurements in the dialog Create Combined File (refer to FIGURE 8.17): the individual measurement which ranks first in the list Combined File has the priority 1. With the combined file, in case of scan points measured twice, the video image will be displayed with the geometry data, measurement data etc. from that individual measurement which contains these scan points and has the highest priority.

Sort individual measurements

To adapt the display, you have to change the order of the files. To do so, proceed as follows:

1. Open the dialog Create Combined File. To do so, in the project browser click the combined file with the right mouse button and select Properties in the context menu.

☞ You can only select the Properties if the combined file is not opened.

2. In the list Combined File mark the individual measurement which you want to move.
3. Click ↑ or ↓, to move the selected individual measurement up or down in the list.
4. Click OK.

Apply frequency bands

You can apply frequency bands from one of the individual measurements to the combined file. To do so, proceed as follows:

1. Open the combined file.
2. Open the frequency band definition (refer to SECTION 9.2.2).
3. Holding the left mouse button pressed, drag the entry Frequency Band of the required individual measurement from the project browser to the frequency band definition.
4. Close the frequency band definition. A message box appears with the question whether the frequency bands are to be recalculated.
5. Click Yes.

8.6 Recalculating Data in the Signal Processor (as an Option)

If you want to further analyze measurement data you have already acquired, you can recalculate it and present the results in a direct comparison with the original data. For this purpose the signal processor is available which you can transfer the data to and can then process it further. The data calculated this way is shown in the analyzer of the signal processor. You can also save this data with the scan and display it again at any time. Please read on this:

- Making a Calculation, refer to SECTION 8.6.1
- Saving Calculated Data, refer to SECTION 8.6.2
- Displaying Measurement Results, refer to SECTION 8.6.3
- Saving Formulae, refer to SECTION 8.6.4
- Application Examples for Editing Measurement Data, refer to SECTION 8.6.5

8.6.1 Making a Calculation

To recalculate the data, you have to open the respective scan, transfer the measurement data to the signal processor and carry out the required arithmetic operations there.

Open the signal processor

To open the signal processor, select File > New > Signal Processor. The signal processor appears.

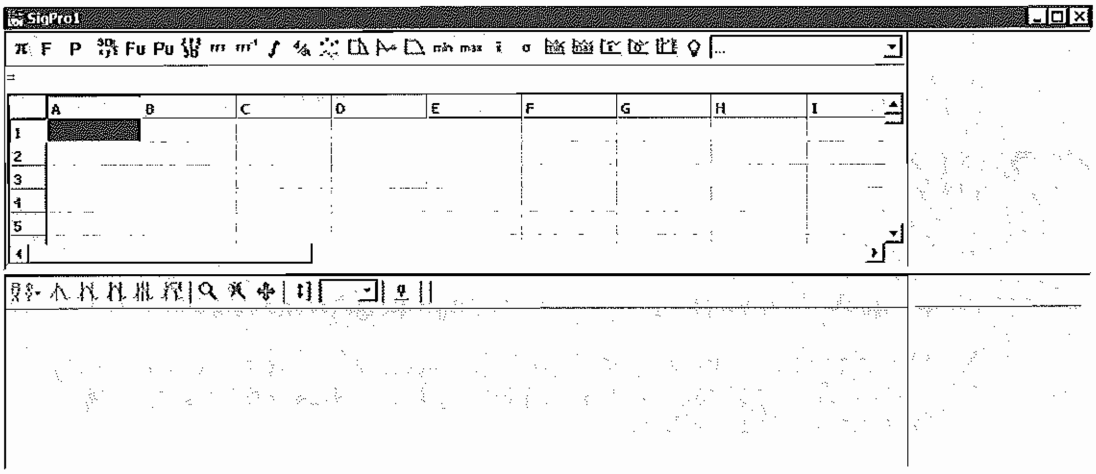


Figure 8.23: Signal processor

You will find a description of the signal processor in SECTION 2.6.6.

Open a scan

1. To open the scan in the presentation window, click or select File > Open. The dialog Open appears.

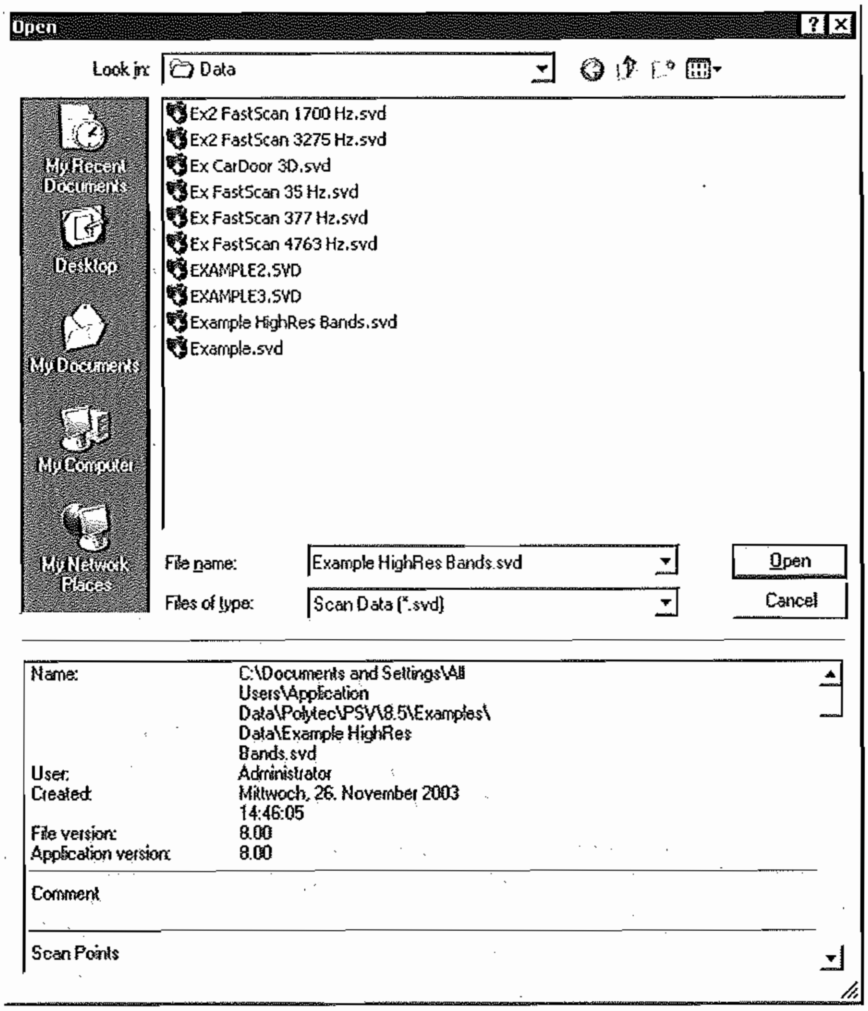


Figure 8.24: Dialog Open

2. Navigate to the saving location and select the file type and name. To make it easier to identify the files, you see meta-information at the bottom in the dialog – for example, the data acquisition board and the settings with which the data was measured.

3. Click Open. If you open a scan, a presentation window appears. If you open a single point measurement, an analyzer appears.

Recalculate measurement data

To recalculate the data in the open file, please proceed as follows:

1. In the presentation window, use the mouse to select one or more scan points, click with the right mouse button and select Copy Selected Points in the context menu. The data of the selected scan point(s) is copied.

   or

   Select Copy All Points in the context menu. The data from all scan points will be copied.

or

1. If you have selected the view Average Spectrum, click the analyzer with the right mouse button and select Copy in the context menu. The dialog Copy appears.

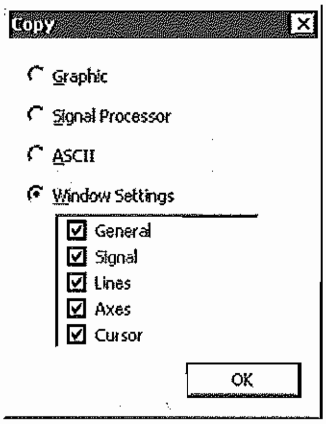


Figure 8.25: Dialog Copy

Select Signal Processor and click OK. The data is copied.

2. Change to the signal processor.

3. Click a cell (e.g. A1) with the right mouse button and select Paste or Paste Link in the context menu. The copied data is inserted in the signal processor or inserted and linked.

☞ Inserted data contains a reference to the original file and remains in the corresponding cell, even if you select other data in the sequence or close the scan or the signal processor. Linked data in contrast is updated in the formula as soon as you select other scan points and is lost as soon as you close the scan or the signal processor.

4. If you have selected and pasted several scan points and want to display the data for a single scan point, select it in the index in the signal processor analyzer (refer to FIGURE 8.26).

5. If you want to display certain frames for the selected scan points, click the number of the particular frames in the analyzer of the signal processor. After calculating you can display an individual graph for every frame (refer to FIGURE 8.26 and SECTION 8.6.3).

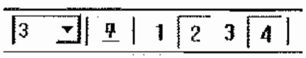


Figure 8.26: Selection of index and frames in the analyzer of the signal processor

6. Click another cell (e.g. A2) and then activate the input line by clicking it.

☞ You can insert a reference to another cell into the formula by holding the Alt key pressed and then clicking the required cell.

7. Here you enter the required command and confirm it with Enter.

You can also use the icons to enter some commands in the formulae editor directly or you can take over the formula in the formulae editor by clicking it in the list next to the icon for the function wizard. You can also use the function wizard.

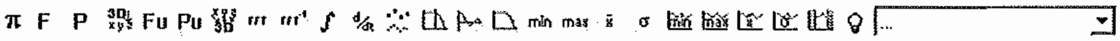


Figure 8.27: Icons for calculations in the signal processor

To activate the function wizard, click 💡. Then when you click one of the icons, a dialog is opened which supports you entering the parameters. You will find an example of the function wizard in SECTION 8.6.5 under Post processing time series. The signal processor carries out this calculation and shows the results in the analyzer.

☞ You will find an overview of the formulae stored in the signal processor in TABLE 8.3. You will find application examples for the signal processor in SECTION 8.6.5.

☞ You can also enter any comments you like as text in the individual cells. In this case you just do not set an equal sign at the start of the respective text. Invalid formulae are shown in red.

Table 8.3: Overview of the arithmetic operations of the signal processor

Command	Icon	Arithmetic operation
Add (+)		By entering + you add two scalars, two strings, two Vib data sets or one Vib data set and one scalar or join two sets.
Sub (–)		By entering – you subtract two scalars, two Vib data sets or one Vib data set and a scalar or two sets.
Mul (*)		By entering * you multiply two scalars, two Vib data sets or one Vib data set with a scalar or intersect two sets.
Div (/)		By entering / you divide two scalars or two Vib data sets by each other, one Vib data set by a scalar or one scalar by a Vib data set.
Card		By entering Card you calculate the cardinality (number of elements) in a set.
Power (^)		By entering ^ you raise the value of x to the power of y (written like: x^y, i.e. x^y); x and y can be scalars or Vib data sets.
The following arithmetic operations apply for a scalar or Vib data set:		
Re		By entering Re you calculate the real part.
Im		By entering Im you calculate the imaginary part.
Abs		By entering Abs you calculate the absolute value.
Arg		By entering Arg you calculate the phase.
Exp		By entering Exp you calculate the exponential function.
Ln		By entering Ln you calculate the natural logarithm (base e).
Sin		By entering Sin you calculate the sine (radian).
Cos		By entering Cos you calculate the cosine (radian).
Tan		By entering Tan you calculate the tangent (radian).
ASin		By entering ASin you calculate the arc sine (radian).
ACos		By entering ACos you calculate the arc cosine (radian).

Table 8.3: Overview of the arithmetic operations of the signal processor

Command	Icon	Arithmetic operation
ATan		By entering ATan you calculate the arc tangent (radian).
Sign		By entering Sign you calculate the sign of the value x. The result is -1 for x = negative, +1 for x = positive and 0 for x = 0.
Deg		By entering Deg you convert radians into degrees.
Rad		By entering Rad you convert degrees into radians.
Round(x)		By entering Round you round real numbers to the next integer e.g. Round(1.1) = 1 or Round(1.9) = 2
Ceil(x)		By entering Ceil you round up real numbers to the next integer e.g. Ceil(1.1) = 2 or Ceil(1.9) = 2
Floor(x)		By entering Floor you round down real numbers to the next integer e.g. Floor(1.1) = 1 or Floor(1.9) = 1
Pi	π	By entering Pi you add the constant π to the formula.
Frame	F	By entering Frame you extract the specified frame or frames from the Vib data set. If the second parameter is a scalar, its real part is rounded up or down to the next integer and its imaginary part is ignored.
Point	P	By entering Point you extract the specified sample point or points from the Vib data set. If the second parameter is a scalar, its real part is rounded up or down to the next integer and its imaginary part is ignored.
ReIndex		By entering ReIndex you change the indices of the measurement points of a Vib data set. Parameter: ReIndex(VibData, [SrcInd, DstInd]) Requirements: - SrcInd and DstInd can each be an IndexSet or an individual index. - SrcInd is optional with Default {*} and DstInd is optional with Default 0 - From SrcInd and the IndexSet of VibData an intersection is formed. This intersection must have the same number of elements as DstInd otherwise an error message appears. - The intersection of DstInd and the IndexSet of VibData must be empty. The measurement points from SrcInd get then the indices of DstInd whereby their order remains conserved. Example 1: ReIndex(VibData, {*}, 0) = ReIndex(VibData) This changes the index to 0 for a Vib data set which contains an individual sample point. Example 2: VibData has the measurement points 1...100; ReIndex(VibData, {21..30}, {101..110}) The result has the indices 1..20, 31..110.
FrameUnion (VibData)	Fu	By entering FrameUnion you combine the frames of up to 10 Vib data sets. The maximum total number of combined frames is 12. You can use this to compare a sample point with an identical index from different measurements.
PointUnion (VibData)	Pu	By entering PointUnion you combine the sample points of up to 10 Vib data sets. If sample points occur in more than one data set, those found first are used.
DisplayUnion (VibData)		By entering DisplayUnion you combine the frames of up to 10 Vib data sets. The maximum total number of combined frames is 12. You can use this to compare sample points with a different index from different measurements if each of the measurements only contains one sample point respectively.

Table 8.3: Overview of the arithmetic operations of the signal processor

Command	Icon	Arithmetic operation
Extract		By entering Extract you extract the specified frequency line numbers or samples. The default starting value is 0 and the full scale value is the maximum number -1. The full scale value must be larger than the starting value.
ExtractX (VibData, xMin, xMax)		ExtractX works in the same way as Extract. Here, however, you enter only start and end of the range to be extracted in the physical quantity of the x-axis (Hz or s).
FFT	FFT	By entering FFT you calculate the Fourier Transformation of the Vib data set. Parameter: FFT(VibData1, [Lines, Window, WndPar1, WndPar2]) Requirements: - VibData1 must be a real signal. - The lines must be in the range of 25...1 048 576. If you do not specify the lines, the maximum possible number will be assumed. - The length of the vector for the Vib data set must be at least twice the number of lines, rounded up to the next power of 2. - The window function (Window) has to be on of the following character strings: "Rectangle" "Bartlett" "Blackman Harris" "Exponential" "Flat Top" "Force" "Hamming" "Hanning" "Tapered Hanning" If you do not specify any type of window, "Rectangle" will be assumed. - WndPar1 and WndPar2 are parameters of the selected window function if applicable (refer also to SECTION 6.2.5). Please note that WndPar2 is not currently used.
Integrate	∫	By entering Integrate you integrate the Vib data set. Requirement: The input data must be real.
Differentiate	d/dt	By entering Differentiate you differentiate the Vib data set. Requirement: The input data must be real.
Resample		By entering Resample you have the Vib data set sampled again at the new specified sample rate. Requirement: The input data must be real.
IFFT	FFT-1	By entering IFFT you calculate the inverse Fourier Transformation. Note: With a measurement which is not triggered, the phase in the Vib channel is replaced by the differential phase to the Ref channel. The calculation of the inverse FFT can provide unexpected results which are hard to interpret.
Filter		By entering Filter you filter a Vib data set. Requirement: The input data must be real. For Type select one of the character strings "low pass", "high pass", "band-pass" or "notch". For Quality select one of the character strings "very low", "low", "medium", "high" or "very high". For Flow select the cutoff frequency for low pass and high pass and the lower cutoff frequency for band-pass and notch. For Fhigh select the upper cutoff frequency for band-pass and notch.

Table 8.3: Overview of the arithmetic operations of the signal processor

Command	Icon	Arithmetic operation
FilterCoeff		By entering FilterCoeff you calculate a Vib data set which contains the filter core of the selected filter. For Fsamp enter the sample frequency. For Type select one of the character strings "low pass", "high pass", "band-pass" or "notch". For Quality select one of the character strings "very low", "low", "medium", "high" or "very high". For Flow select the cutoff frequency for low pass and high pass and the lower cutoff frequency for band-pass and notch. For Fhigh select the upper cutoff frequency for band-pass and notch.
Transmission		By entering Transmission you calculate a Vib data set which contains the transmission function of the selected filter. For Fsamp enter the sample frequency. For Type select one of the character strings "low pass", "high pass", "band-pass" or "notch". For Quality select one of the character strings "very low", "low", "medium", "high" or "very high". For Flow select the cutoff frequency for low pass and high pass and the lower cutoff frequency for band-pass and notch. For Fhigh select the upper cutoff frequency for band-pass and notch. For Count enter the number of frequency lines for which the transmission function is to be calculated.
Min, Max, Mean, StdDev	min max $\bar{x}$ σ	By entering Min, Mean, Max or StdDev, you respectively calculate the minimum, average or maximum of a deviation or the standard deviation of a Vib data set which contains an individual sample point. The return value is a scalar. You can calculate Mean for real or complex data. You can only apply all the other functions to real data.
ArgMin, ArgMax (VibData)		By entering ArgMin or ArgMax the abscissa (x-coordinate) of the minimum or maximum in a real Vib data set which contains an individual sample point is given.

Table 8.3: Overview of the arithmetic operations of the signal processor

Command	Icon	Arithmetic operation
StatMin, StatMax, StatMean, StatStdDev		By entering StatMin, StatMean, StatMax or StatStdDev, you respectively calculate the minimum, average or maximum of a deviation or the standard deviation of a Vib data set. The return value is a Vib data set with an individual measurement point with the index 0. You can calculate StatMean for real or complex data. You can only apply all the other functions to real data. ☞ It can make sense to apply StatMean to a data set which only contains a single measurement point. This does not change the data set but means that the point index is set to 0. Points with the index 0 can be compared to all other indexed points.
Scale (VibData, xMin, xMax, xName, xUnit, yMin, yMax, yName, yUnit, yScale, Name, 0dBReference, Power)		By entering Scale you modify scaling information of a Vib data set. This function is usually used to adapt the scaling after operations such as FFT or Integrate as these operations change the dimensions of the axes. The following list contains the changes you can make using the command Scale. - VibData: Data set - xMin, xMax: Boundaries of the x-axis - xName: Name of the x-axis - xUnit: Unit of the x-axis - yMin, yMax: Boundaries of the y-axis - yName: Name of the y-axis - yUnit: Unit of the y-axis - yScale: The y values are multiplied with yScale - Name: Name of the data set - 0dBReference: Reference value of the dB display - Power: 1 or 2 Power = 1 shows that it is a power signal. 10dB then corresponds to a multiple of ten. For other signals you set Power = 0.20dB corresponds to a multiple of 10.
Resolution (VibData)		By entering Resolution the distance between the frequency lines or samples of a Vib data set are given.
NumValues (VibData)		By entering NumValues the number of samples or frequency lines of a Vib data set is given.
Points (VibData)		By entering Points the set of sample points in a Vib data set is given.
Abscissa (VibData)		By entering Abscissa a Vib data set of a sample point with the index 0 is emitted for which the ordinates (y-axis) show that same values as the abscissa (x-axis).
Direction (VibData, dir)		By entering Direction you extract the data in vibrational direction of a 3D Vib data set. The direction is set with the variables dir (0 for x-direction, 1 for y-direction, 2 for z-direction)
Make3D (VibData)		By entering Make3D you combine 1D Vib data sets to a 3D Vib data set. If you combine less than three Vib data sets, the missing ones are replaced with 0.

☞ In the table cells, you can display either the formula or the result. To switch over, select View > Formulae or press the key combination Ctrl+#.

You can also enter sets and complex numbers. You place sets in curly brackets and complex numbers as an option in round brackets. In TABLE 8.4 and TABLE 8.5 the input conventions are explained on the basis of examples.

Table 8.4: Examples for entering sets

Command	Meaning
{1,2}	1 and 2
{1:5} or {1..5}	1 to 5
{1,4,7...9}	1, 4 and 7 to 9
{}	empty set
{*}	general set

Table 8.5: Examples for entering complex numbers

Command	Meaning
0;1 or (0;1)	i
−1.23E4;−5.67E8 or(−1.23E4;−5.67E8)	− 1.23E4 − 5.67E8 · i

Cell links

You will find a description what kind of cell links you can generate in the signal processor in SECTION 2.6.6 under Calculation table. A distinction is made between relative and absolute cell links:

Relative Cell Links: If you create a formula, the references to cells are shown relative to the position of the cell which contains the formula. For example the cell B6 contains the formula =A5. The signal processor searches the value in the cell which is located one cell above and one cell on the left of B6. References of this type are called relative cell links. If you copy a formula in which relative cell links are used, then the links were automatically adapted after inserting the formula to refer to other cells in relative to the position of the formula.

Absolute Cell Links: If you want to prevent that the links will be adapted when copying a formula in another cell, use an absolute cell link. If, for example, a formula multiply the cell A5 by the cell C1 (=A5*C1) and is copied into another cell, both references will be adapted. You can generate an absolute cell link to the cell C1 by entering a dollar symbol ($) in front of the part of the link that should not be changed. To generate, for example, an absolute cell link to the cell C1 enter (=A5*C1) in the formula.

Example calculations

Differentiation in the Frequency Range

In the following table you will find an example for differentiation in the frequency range.

Cell	Function	Description
A1	=Complex spectrum	From measurement
B1	=IFFT(A1)	Transformation in the time domain
B2	=Differentiate(B1)	Differentiation in the time domain
A2	=2*Pi()*(0;1)*Abscissa(A1)	Multiplication with $2\pi if$ in the frequency range corresponds to a differentiation in the time domain.
A3	=A1*A2	
B3	=IFFT(A3)	Transformation in the time domain

To calculate B2, first of all transform into the time domain and then differentiate there. To calculate B3, multiply in the frequency range with a function which corresponds to a differentiation in the time domain. The result is the same apart from fringe effects and shifts in the order of magnitude of the sampling. Multiplication with $2\pi f$ corresponds to a high pass, multiplication with i of a phase shift by 90°.

Integration in the Frequency Range

In the following table you will find an example for the integration in the frequency range.

Cell	Function	Description
A1	=Complex spectrum	From measurement
B1	=IFFT(A1)	Transformation in the time domain
B2	=Integrate(B1)	Integration in the time domain
A2	=2*Pi()*(0;1)*Abscissa(A1)	Division by $2\pi if$ in the frequency range corresponds to an integration in the time domain.
A3	=A1/A2	
B3	=IFFT(A3)	Transformation in the time domain

To calculate B2 first of all transform into the time domain and then integrate there. To calculate B3, multiply in the frequency range with a function which corresponds to an integration in the time domain. The result is the same apart from an additive constant.

Average over Partition

In the following table you will find an example for creating the average over a partition.

Cell	Function	Description
A1	=Single sample point	From measurement
A2	=(sign(Abscissa(A1)-4000) -sign(Abscissa(A1)-6000)) / 2	Function which has the value 1 in the interval [4 kHz..6 kHz] and has the value 0 outside
A3	=A1*A2	Value outside the interval [4 kHz..6 kHz] are set to 0.
A4	= Mean(A3)/Mean(A2)	Average in the range [4 kHz..6 kHz]

Power Spectral Density

In the following table you will find an example for calculating the power spectral density.

Cell	Function	Description
A1	=Complex spectrum	From measurement
A2	= abs(A1)^2/Resolution(A1)	Power spectral density

☞ You will find detailed examples in SECTION 8.6.5.

Set up the signal description

You can adapt the presentation of the recalculated measurement data in the analyzer. To do so, proceed as follows:

1. Click the cell which contains the recalculated measurement data with the right mouse button and select Signal Description in the context menu. The dialog Signal Description appears.

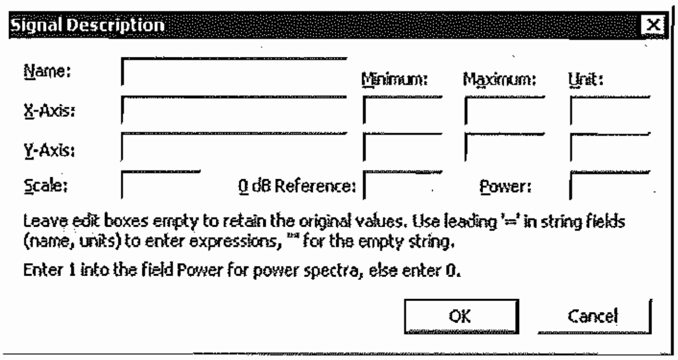


Figure 8.28: Dialog Signal Description

2. Fill in the fields as described in the following and click OK.

☞ Entries in this dialog are saved and shown in any case, even if the input data for the signal calculation changes! If you do not enter anything in a field, the original value from the input data is retained or adapted.

Name: Here you enter the description of the recalculated measurement data. This name is shown in the respective cell. After saving the measurement data it will also appear on the list of available signals in the presentation window, refer also to SECTION 8.6.2.

X-Axis: Here you enter the description for the x-axis.

Y-Axis: Here you enter the description for the y-axis.

Minimum: Here you enter the lower value for the scale of the x- or y-axis.

Maximum: Here you enter the upper value for the scale of the x- or y-axis.

Unit: Here you enter the abbreviation for the unit of the x- or y-axis.

Scale: Here you enter the factor by which the presentation of the measurement values is to be magnified or reduced.

0 dB Reference: If you have selected a view with [dB], here you enter the value which corresponds to 0dB (reference value).

Power: If for example the signal includes a cross power spectrum, here you enter the value 1. If the signal is not a power signal, here you enter the value 0 (default).

8.6.2 Saving Calculated Data

You can add the measurement data which you calculated in the signal processor to the original file as user defined data sets. To do so, you have the following options:

☞ The indices of the scan points in the original file have to match the indices of the data set. If not, only the data with corresponding indices is taken over. The geometry of the objects, i.e. the number of scan points should be the same. If not, a message will appear and you will be asked whether you want to take over the data sets.

1. Mark the cell which contains the recalculated measurement data in the signal processor.
2. Click it with the right mouse button and select Copy in the context menu.
3. Then click with the right mouse button the name of the original file in the project browser and select Paste in the context menu.

Or:

1. Mark the cell which contains the recalculated measurement data in the signal processor.
2. Holding the left mouse button pressed, drag to the presentation window.

Or:

1. Mark the cell which contains the recalculated measurement data in the signal processor.

2. Holding the left mouse button pressed, drag to the name of the original file in the project browser.

You will immediately have another channel available with the name Usr, Usr X, Usr Y, Usr Z or Usr 3D. In the list of signals you will find the recalculated measurement data listed with the name which you entered in the dialog Signal Description.

Properties You can display the properties of the user defined signals and change or delete them. To do so, click and select the channel Usr, Usr X, Usr Y, Usr Z or Usr 3D in the context menu. Then click and select Properties in the context menu. The dialog Properties of User Defined Signals appears.

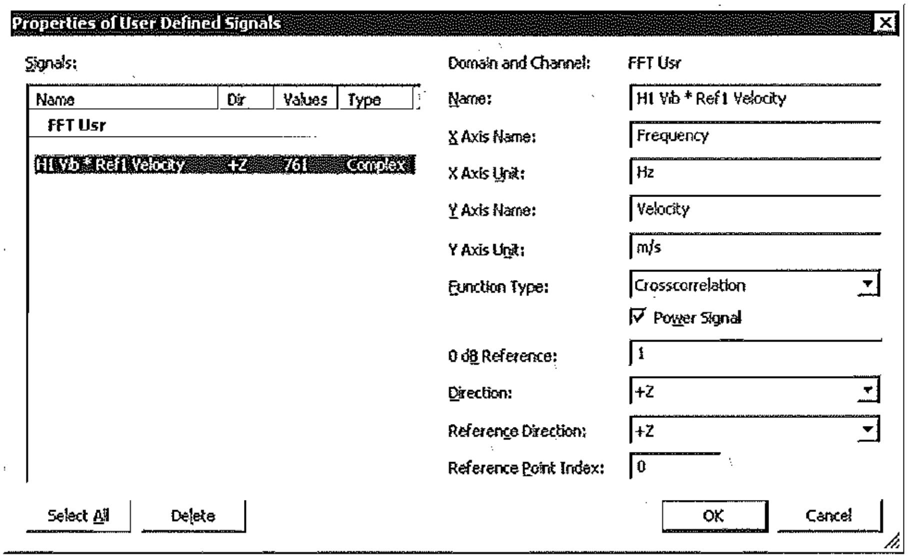


Figure 8.29: Dialog Properties of User Defined Signals

Signals On the left you will see the user defined signals with the name you entered in the dialog Signal Description.

Domain and channel On the right your are shown the domain, channel and name of the signal and other properties. You can change these properties for every signal.

Delete You can delete user defined signals. To do so, mark the signal and click Delete. The user defined data set is deleted from the file.

To set the properties of several user defined signals to the same value, proceed as follows:

1. Mark the corresponding signals in the list. To do so, hold the Control key pressed and click the signals.

2. Enter the desired common property on the right.

3. As soon as you change the signal selection or click OK the changes to the signals are accepted.

8.6.3 Displaying Measurement Results

At the same time as the new calculation of the data, the updated graph is shown in the analyzer. The analyzer of the signal processor has the functions described in SECTION 2.6.3. If you mark several table cells, then you will be shown the respective frames for selection. If you select several frames, you will be shown the respective graphs in parallel.

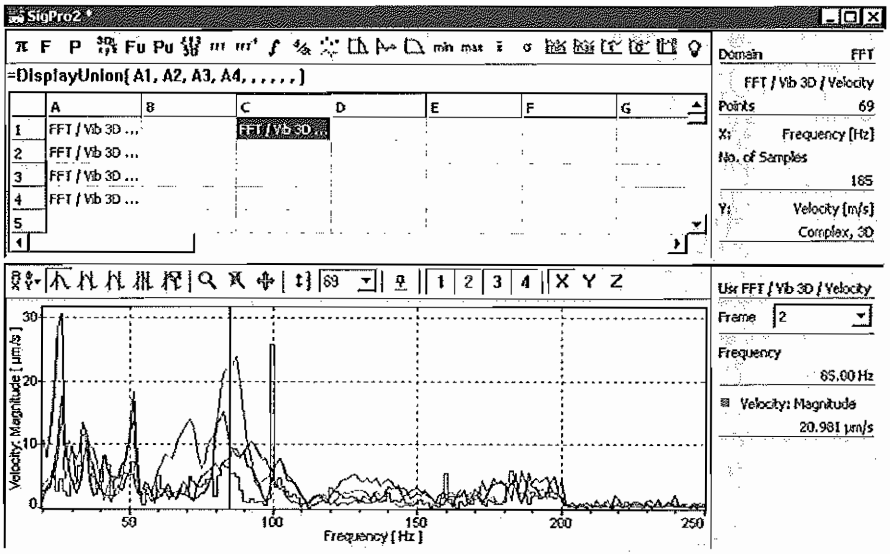


Figure 8.30: Presentation of several graphs in the analyzer

If you would like to stop updating the graph at a certain point in the arithmetic chain, click (Fix). The presentation then corresponds to the contents of the table cell selected at that moment in time. All subsequent arithmetic steps are carried out anyway, but do not have any effect on the presentation of the graph. Changes in the formulae before the position marked with however still have an effect on the adaptation of the presentation up to this point.

8.6.4 Saving Formulae

To save formulae after you have recalculated the measurement data, proceed as follows:

1. Click or select File > Save As. The dialog Save As appears.

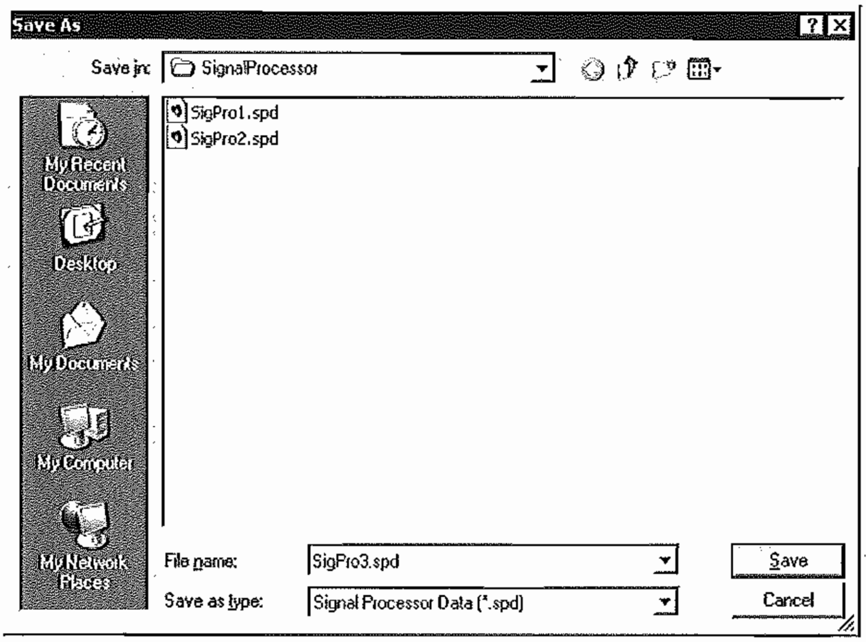


Figure 8.31: Dialog Save As

2. Navigate to the saving location and enter the file name.
3. Click Save.

☞ The file saved in this way does not contain any measurement data itself but only references to data. The reference among other things includes the full path name of the original file. If you move or rename the scan, then the references to the measurement data become invalid. To permanently save your results, you have to add them to the original file. A file in the format Signal processor data (*.spd) does not contain any data, just calculation specifications!

8.6.5 Application Examples for Editing Measurement Data

Complex average spectrum through all scan points

During data acquisition, the software calculates an average spectrum across all scan points. However, it is not complex averaging but the amplitudes of the individual spectra are calculated and these amplitudes are averaged. In this example you are shown how you can use the signal processor in presentation mode to help you calculate the complex averaged spectrum across all scan points and can then save it so that you have access to it at all times.

1. Select File > New > Signal Processor to generate a new signal processor document.
2. Open the file EXAMPLE2.SVD and display in the domain FFT the channel Vib & Ref1 and the signal H1 Velocity / Voltage.
3. In the presentation window click the object with the right mouse button and select Copy All Points in the context menu.
4. Change to the signal processor.
5. Click the cell A1 with the right mouse button and select Paste in the context menu. The data is available in the signal processor document.
6. Select the cell A2. To do so, click it.
7. Here you enter the command =StatMean(A1) and confirm it with Enter. The signal processor calculates the complex average through all scan points and shows this in the analyzer.

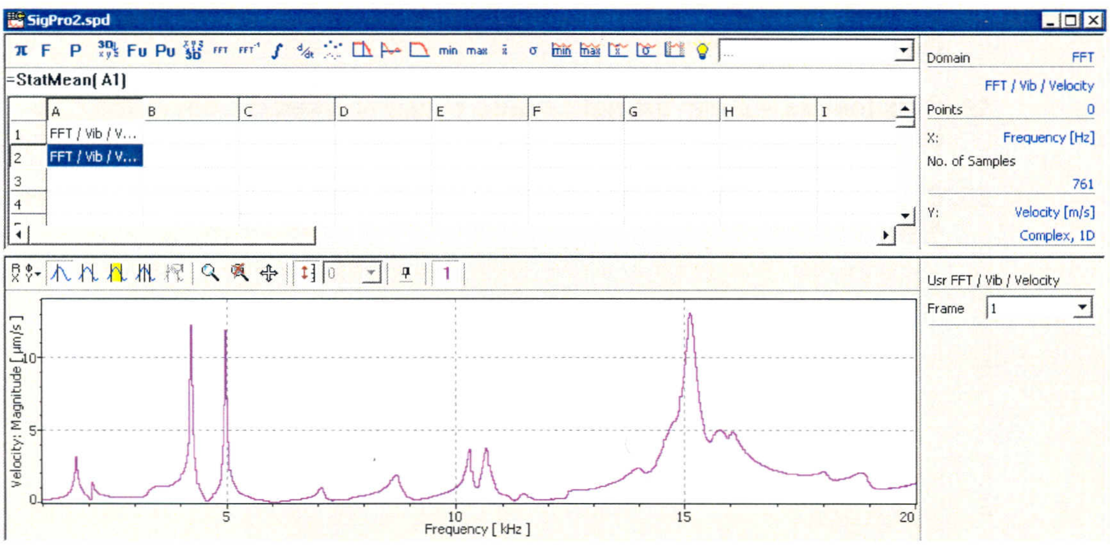


Figure 8.32: Display of the complex average through all scan points

☞ The average through all scan points is given the index 0.

8. Click the R Φ X Y button in the analyzer toolbar and select the view Mag. [dB] & Phase in the context menu to display both the magnitude and also the phase of the average spectrum.

9. Click the cell A2 with the right mouse button and select Signal Description in the context menu. The dialog Signal Description appears.

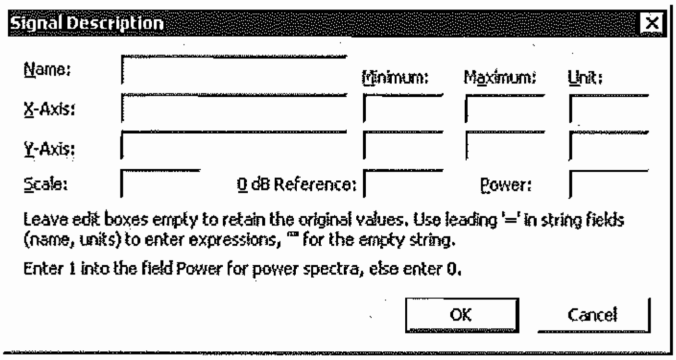


Figure 8.33: Dialog Signal Description

10. In the field Name enter the description Complex Average Spectrum and click OK to close the dialog.

11. Arrange the signal processor and the presentation window so that they are both completely visible. To do so, select Window > Tile Horizontally.

12. Click the cell A2 in the signal processor.

13. Click the cell A2 again and holding the left mouse button pressed, drag the mouse cursor across to the presentation window. Release the mouse button there. This then means that the data in the cell A2 are added to the channel Usr as a user defined signal Complex Average Spectrum.

    Or:

14. Click the cell A2 with the right mouse button and select Copy in the context menu.

15. Change to the presentation window and here, if applicable, select the view Average Spectrum.

16. Select Edit > Insert. The complex average spectrum is added to the document EXAMPLE2.SVD as a user defined signal Usr.

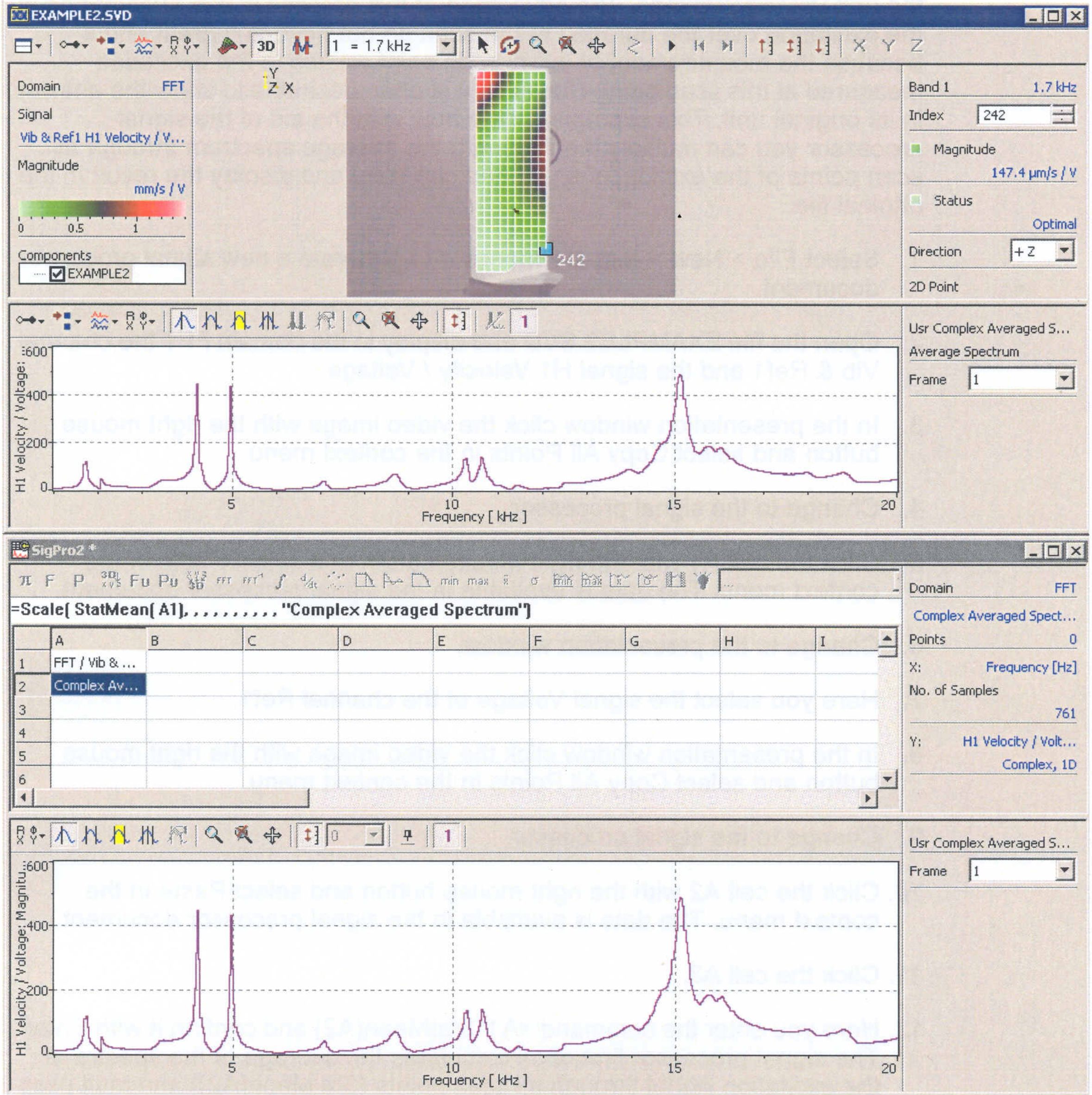


Figure 8.34: Display of complex average spectrum

17. Save this file with a different name. You can now display the complex average spectrum again at any time. To do so, open the file you saved and select

- the view Average Spectrum in the presentation window,
- the channel Usr in the toolbar of the analyzer and
- the signal Complex Average Spectrum in the toolbar of the analyzer.

16. Select Edit > Insert. The complex average spectrum is added to the document EXAMPLE2.SVD as a user defined signal Usr.

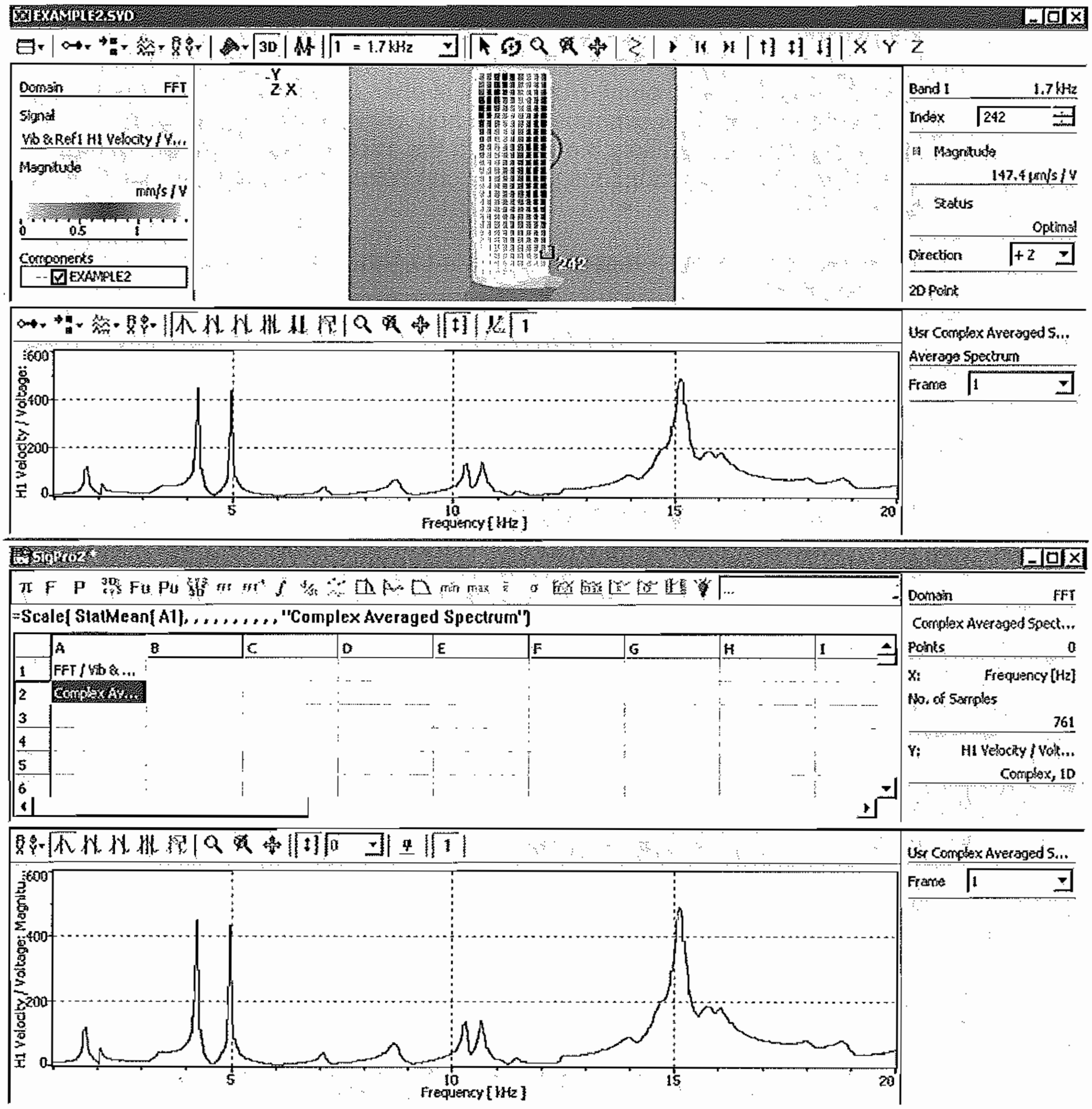


Figure 8.34: Display of complex average spectrum

17. Save this file with a different name. You can now display the complex average spectrum again at any time. To do so, open the file you saved and select

- the view Average Spectrum in the presentation window,
- the channel Usr in the toolbar of the analyzer and
- the signal Complex Average Spectrum in the toolbar of the analyzer.

Multiplication of an FRF with the reference signal

An FRF (Frequency Response Function) is generated by dividing an answer signal (vibrometer signal) by a reference signal (excitation signal). The same applies to the signals H1 and H2. This means that the FRF has for example the unit Velocity/Voltage. The advantage of this process is that fluctuations in the excitation over the duration of the scan do not have any great effect because the measurement at every scan point relates to the excitation measured at this scan point. However, it is often desirable to show the answer in its original unit. This example shows how with the aid of the signal processor you can multiply the FRF with the average spectrum through all scan points of the excitation signal and can save and display the result in the original file.

1. Select File > New > Signal Processor to generate a new signal processor document.
2. Open the file EXAMPLE2.SVD and display in the domain FFT the channel Vib & Ref1 and the signal H1 Velocity / Voltage.
3. In the presentation window click the video image with the right mouse button and select Copy All Points in the context menu.
4. Change to the signal processor.
5. Click the cell A1 with the right mouse button and select Paste in the context menu. The data is available in the signal processor document.
6. Change to the presentation window.
7. Here you select the signal Voltage of the channel Ref1.
8. In the presentation window click the video image with the right mouse button and select Copy All Points in the context menu.
9. Change to the signal processor.
10. Click the cell A2 with the right mouse button and select Paste in the context menu. The data is available in the signal processor document.
11. Click the cell A3.
12. Here you enter the command =A1*StatMean(A2) and confirm it with Enter. The signal processor first of all calculates the average of the spectra of the excitation signal through all scan points (StatMean(A2)) and multiplies the result at every spectrum of the signal H1, which is taken from the cell A1. The result is shown in the cell A3.
13. Click the cell A3 with the right mouse button and select Signal Description in the context menu. The dialog Signal Description appears (refer also to FIGURE 8.33).
14. In the field Name enter the description H1 Vib * Ref1 Velocity.

☞ For the functions Integrate, Differentiate, FFT and IFFT the software automatically adapts the axis name and the unit. For the other functions, enter the name in the dialog.

15. In the field Y-Axis, enter the description Velocity.

16. In the field Unit of the Y-Axis enter the unit m/s and click OK to close the dialog.

17. Arrange the signal processor and the presentation window so that they are both completely visible. To do so, select Window > Tile Horizontally.

18. Click the cell A3 in the signal processor.

19. Click the cell A3 again and holding the left mouse button pressed, drag the mouse cursor across to the presentation window. Release the mouse button there. This means then that the data in the cell A3 are added to the channel Usr as a user defined signal H1 Vib * Ref1 Velocity.

20. Change to the presentation window.

21. Here you select the view Single Scan Point.

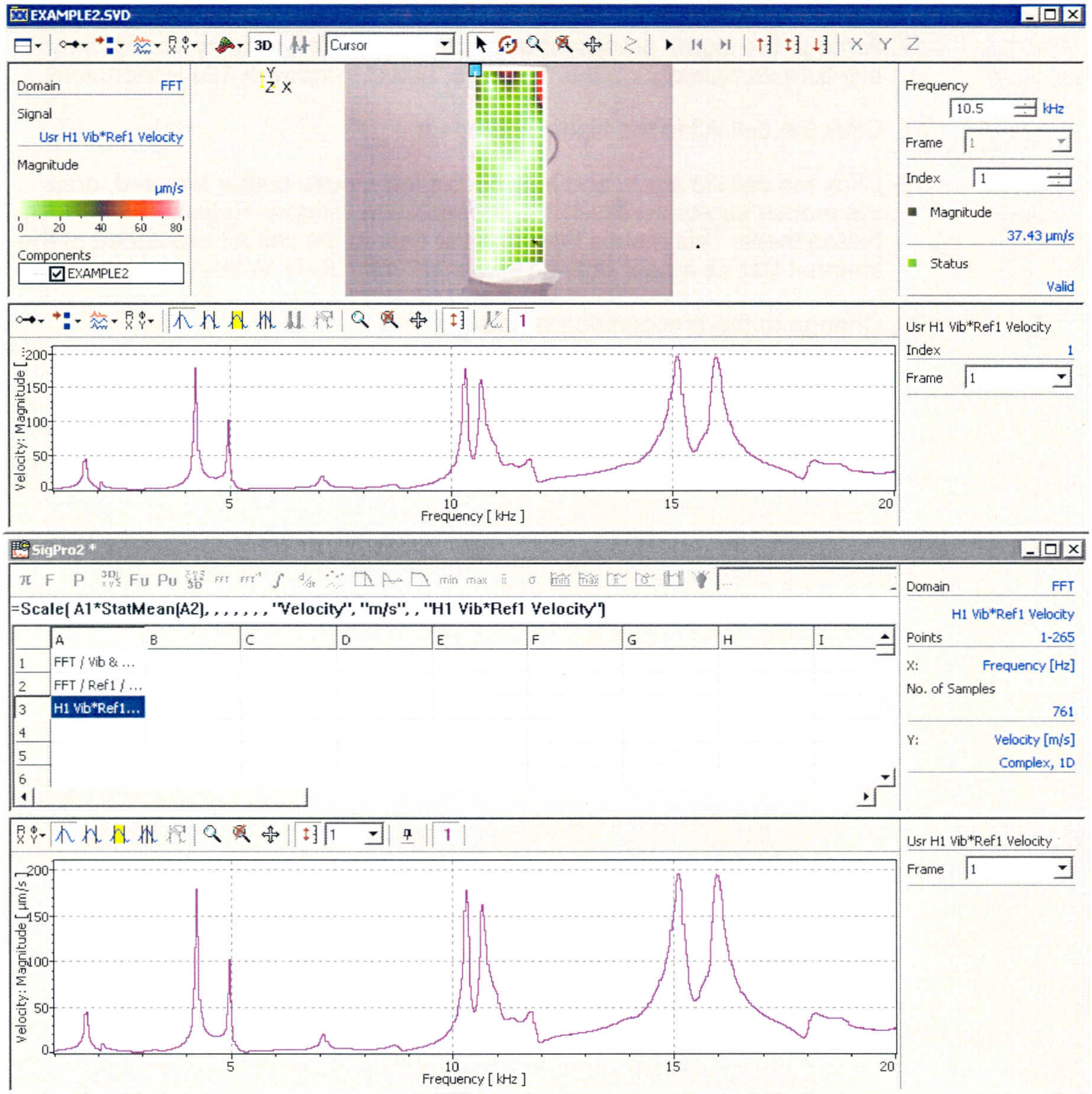


Figure 8.35: Display of the multiplication of FRF and reference signal

22. Save this file with a different name. From now on you can display the signal H1 multiplied with the average spectrum of the reference channel at any time. To do so, open the file you saved and select the channel Usr and the signal H1 Vib * Ref1 Velocity in the presentation window.

Post processing time series

With the software option Time Domain Data, you can also capture data in the domain Time. With the aid of the signal processor this data can be evaluated. The following example shows the analysis of a time series of the response of a loudspeaker to a rectangular excitation signal.

1. Select File > New > Signal Processor to generate a new signal processor document.
2. Open the file Ex Time.pvd and display in the domain Time the channel Vib and the signal Velocity.
3. Click the analyzer with the right mouse button and select Copy in the context menu. The dialog Copy appears.
4. Select Signal Processor, click OK and change to the signal processor.
5. Click the cell A1 with the right mouse button and select Paste in the context menu. The data is available in the signal processor document.
6. Click the cell A1. In the analyzer of the signal processor you will see a graphic representation of the time series measured.
7. Click the cell A2.
8. Here you enter the command =Integrate(A1) and confirm it with Enter.
9. Click the cell A2 with the right mouse button and select Signal Description in the context menu. The dialog Signal Description appears (refer also to FIGURE 8.33).
10. In the field Name, enter the description Integrated to Displacement.

☞ For the functions Integrate, Differentiate, FFT and IFFT the software automatically adapts the axis name and the unit. For the other functions, enter the name in the dialog.

11. In the field Y-Axis, enter the description Displacement.
12. In the field Minimum of the Y-Axis, enter the value –10e–6.
13. In the field Maximum of the Y-axis, enter the value 10e–6.
14. In the field Unit of the Y-Axis enter the unit m and click OK to close the dialog.

    The analyzer will now display the displacement signal gained by integrating the velocity signal. Along the time axis you will be able to see a linear decay in the signal. This decay is caused by a negative offset on the velocity signal which has an increased effect due to insufficient modulation of the data acquisition board when acquiring the velocity signal.

15. Copy the contents of cell A2 into cell B2. To do so, select cell A2 and press the key combination Ctrl+C. Then select cell B2 and press the key combination Ctrl+V.
16. Click in the formulae editor where the formula from cell B2 is displayed.

17. There replace the parameter (A1) of the function Integrate by entering (A1-Mean(A1)) and confirm the changing with Enter.

    This changing to the formula means that the offset from the time series is subtracted in cell A1. For this purpose, first of all the average of the time series is determined and this average is subtracted from every time value in the time series. As the time series is periodic in the time window measured, this has the effect of completely correcting for the offset. Then the integration is calculated.

18. Click the cell B2.

19. Then also select the cell A2. To do so, hold the control key pressed and click the cell A2.

    The analyzer in the signal processor now shows two graphs. One corresponds to the signal in cell B2 and one to the signal in cell A2. Through a direct comparison of the graphs you can clearly see the disappearance of the linear decay by correction of the offset.

20. Click the cell B3 and activate the input line. Then click FFT in the toolbar of the signal processor. This command inserts a template for the function FFT into the input field and the formulae editor.

    Replace the descriptions VibData with B2, Lines with 256 and Window with "Rectangle" and delete the two descriptions WindowParameter. In doing so, make sure that you put the value "Rectangle" in inverted commas.

    Alternatively click the cell B3, activate the input line, click and then FFT . The dialog Function Wizard appears.

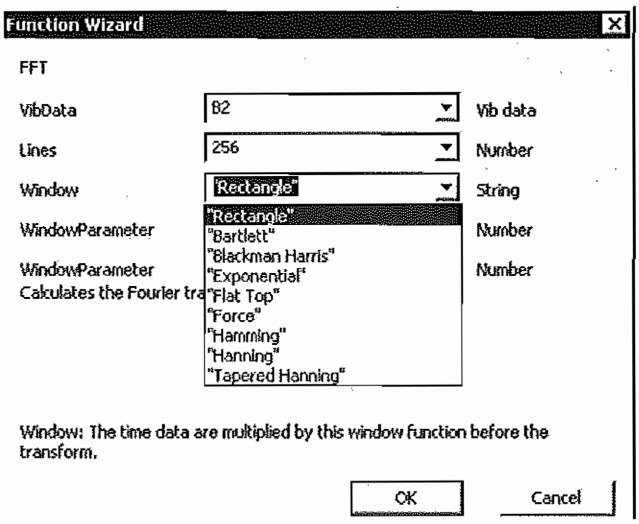


Figure 8.36: Dialog Function Wizard

    Here you enter the above mentioned values and click OK.

21. Confirm the change with Enter.

22. Click the cell B3 with the right mouse button and select Signal Description in the context menu. The dialog Signal Description appears (refer also to FIGURE 8.33).

23. In the field Name, enter the description FFT Displacement.

24. In the field X-Axis, enter the description Frequency.

25. In the field Unit of the X-Axis, enter the unit Hz and click OK to close the dialog.

    From the 512 samples of the integrated time series in cell B2, the signal processor will now calculate an FFT with 256 lines and will display this in the analyzer.

26. Arrange the signal processor and the presentation window so that they are both completely visible. To do so, select Window > Tile Horizontally.

27. Click the cell B2 in the signal processor.

28. Click the cell B2 again and holding the left mouse button pressed, drag the mouse cursor to the analyzer. Release the mouse button there. This process adds the data in cell B2 as a user defined signal Integrated to Displacement to the channel Usr.

29. Repeat steps 27 and 28 for the cell B3. Thus you add the contents of the cell as a user defined signal FFT Displacement.

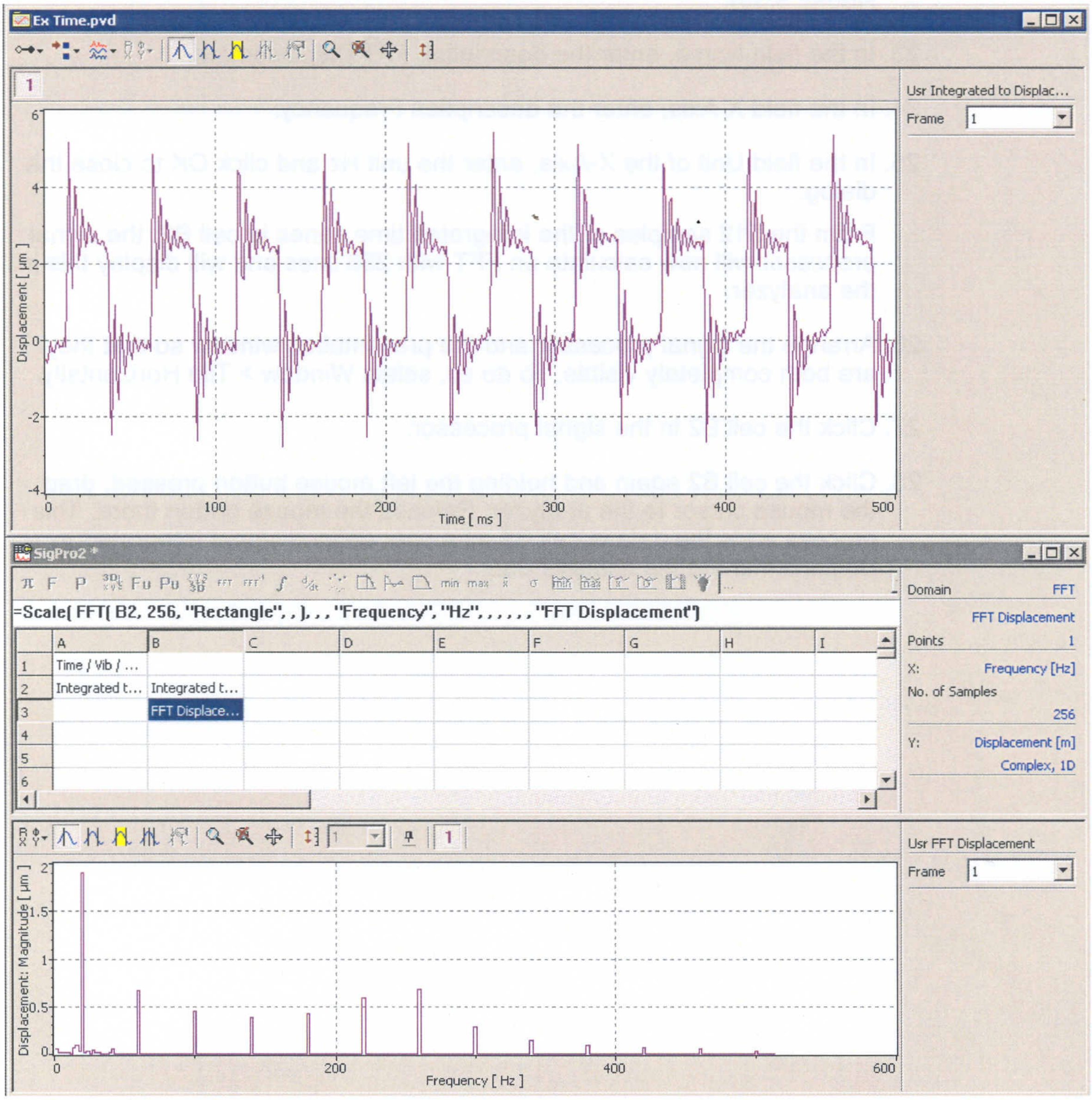


Figure 8.37: Display of post processing time series

30. Save this file with a different name. You can now display the integrated time series and the FFT calculated from it at any time. To do so, open the file you saved and select the channel Usr in the domain FFT or Time.

8.7 Creating a New Scan File

If you want to add user-defined data sets to already recorded 3D geometries, you have to create a new scan file. To do so, proceed as follows:

1. Click and select Scan File in the context menu or select File > New > Scan File. The dialog Open appears.

☞ You can also use the command Create Scan File in the project browser. See also SECTION 2.6.4 on this.

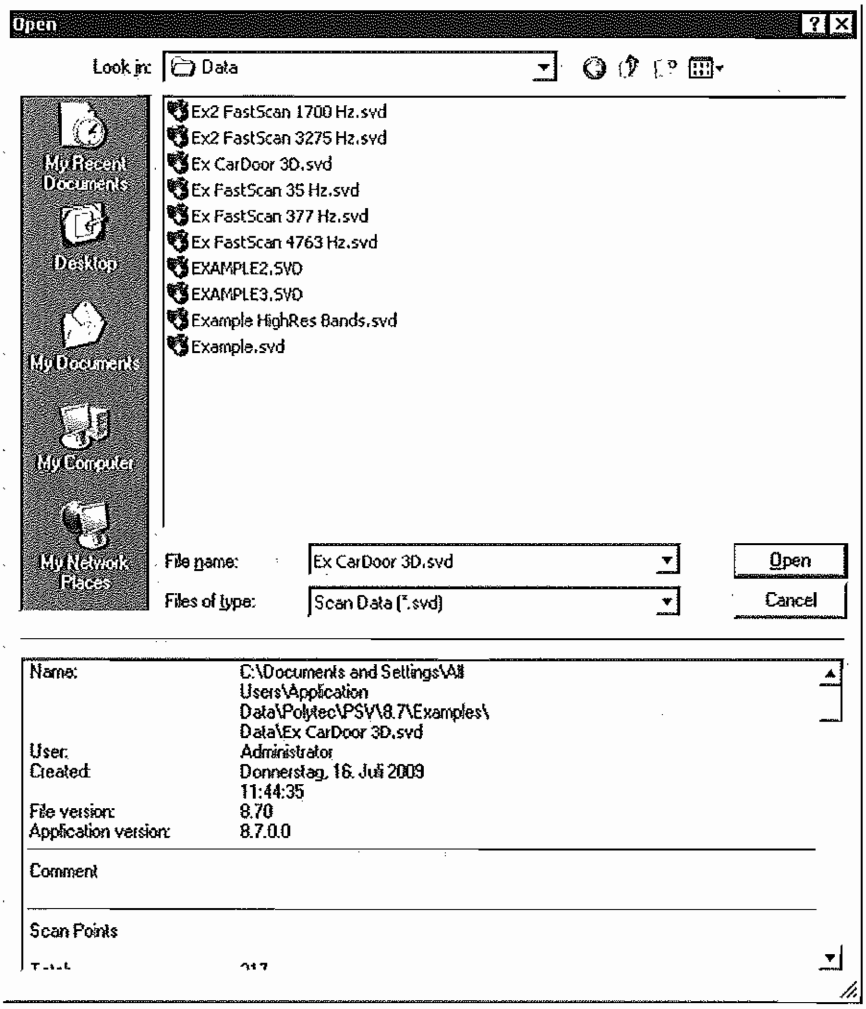


Figure 8.38: Dialog Open

2. Navigate to the saving location and select the file type and name. To make it easier to identify the files, look at meta-information at the bottom in the dialog – for example, the data acquisition board and the settings with which the data was measured.

☞ You can create the scan file from files of the following formats: Scan Data (svd), Settings Files (set), Universal Files (unv), or ME'Scope Files (str)

3. Click Open. Only the 3D geometry is transferred to the new scan file. You will get an error message if the selected file does not contain a 3D geometry.

4. You can now add user-defined data sets and then save the file.

9 Evaluating Scans

The software offers numerous possibilities to evaluate scans. To do this, first open the scan as described in SECTION 10.1.2. Depending on which measurement mode you used to acquire the data, you will see the results of your measurement in the time or frequency range.

You can see which mode a measurement was made in by opening the additional information in the dialog at the bottom of a file. Read SECTION 10.1.1 on this.

If you have opened a scan, you will see in the status bar which mode the measurement was made in.

If you open a scan, which has been generated in FFT mode, in presentation mode for the first time, you will see the root mean square of the magnitude over the entire bandwidth. You can apply certain evaluation functions directly to the root mean square. See SECTION 9.1 and SECTION 9.3 on this. You can also evaluate sections of the measured spectrum – for example, in the proximity of resonance or 1/3 octave bands. First of all you have to define these frequency bands as described in SECTION 9.2. At the peak frequencies of the frequency bands you can also animate the vibration, see SECTION 9.4 on this. You can also evaluate the spectrum with a single cursor, see SECTION 9.2.1 on this.

In FastScan mode you only measure a certain individual frequency. Correspondingly you will only see a surface-like presentation of the data of this frequency if you open the scan in presentation mode.

If you open a scan generated in Time mode for the first time in presentation mode, you will see the root mean square of the magnitude over the whole sample time. With the time data animation you can present the momentary magnitude of the sample time for selected ranges.

9.1 Processing Data

You can prepare a scan for display with the following commands in the menus Edit and Presentation:

- Invalidated
- Valid
- Validate All Points
- Invalidate Not Optimal Points
- Filter Data
- Interpolate Invalid Points
- Interpolate Disabled Points

Apart from that, you can change the specification of the vibrational direction.

You can undo some commands.

In presentation mode you can mark the scan points you have already measured to be remeasured. To do so, allocate the points the scan status Invalidated as described in the following. Then change back into acquisition mode and open the file to remeasure as described in SECTION 7.2.

In principle, you could allocate all scan points the scan status Invalidated, but this is only necessary for those points which have not provided any meaningful measurement result (e.g. those with a bad signal-to-noise ratio). For scan points with the scan status Invalidated the software does not display any measurement data. The averaged spectrum over all scan points is corrected correspondingly.

☞ Scan points with the status Optimal can only be present if Signal Enhancement was active during scanning (refer to SECTION 7.8.1 and SECTION 6.2.7).

Invalidate

To allocate the status Invalidated to one or more scan points, proceed as follows:

1. Place a cursor at the scan point or scan points. See SECTION 8.3.4 on this.
2. Click one scan point using the right mouse button and select Invalidate in the context menu or select Edit > Modify Selected Points > Invalidate.

Validate

3. To return to the original status of the scan points, click one scan point using the right mouse button and select Validate in the context menu or select Edit > Modify Selected Points > Validate.

Validate All Points

To allocate all scan points their original status, select Edit > Validate All Points.

Invalidate Not Optimal Points

You can allocate the status Invalidated to all scan points which do not have the status Optimal. This command is only active if

- Signal Enhancement was active during scanning (refer to SECTION 7.8.1 and SECTION 6.2.7)
- not all scan points have got the status Optimal.

To do this, proceed as follows:

1. Select Edit > Invalidate Not Optimal Points.
2. To return to the original status of the scan points, select Edit > Invalidate Not Optimal Points again.

☞ If you had changed the status of single scan points with the command Invalidate (see above), these scan points are also allocated their original status.

Filter Data

You can smooth the presentation of scans with a filter. Filtering is done on two levels. First of all median averaging and then center value filtering of neighboring scan points is carried out.

To smooth the presentation, proceed as follows:

1. Select Presentation > Filter Data.
2. To undo the command, select Presentation > Filter Data again.

☞ If Filter Data is active, then in ASCII export the smoothened values are saved. If you export as Universal File and ME'Scope or access via Polytec File Access, you will obtain the original data.

☞ The commands Interpolate Data and Filter Data represent measures taken to rid measurements of interference signals and noise levels. When defining the quantity of scan points, already ensure that there is a sufficient scan point density, depending on the maximum vibration frequency in the object to be measured. Careful scan point definition also helps avoiding interference signals caused by unsuitable selection of scan points, e.g. glancing incidence at the edge of an object or undesirable measuring in object openings.

Interpolate points

For scan points with the status Overrange, Invalidated or Disabled the software does not display any measurement data. You can interpolate and display data from neighboring scan points for these scan points. If you have user-defined data sets available, you can disable, interpolate, and show points individually for each data set. The original data remain unaffected.

☞ The software allocates the status Overrange while scanning. You can allocate the status Invalidated manually (see above). You can allocate the status Disabled manually before scanning (refer to SECTION 5.4.2).

To interpolate points with the status Overrange or Invalidated, proceed as follows:

1. Select Presentation > Interpolate Invalid Points. If you would like to interpolate not optimal points as well, then in addition to that select Edit > Invalidate Not Optimal Points before.
2. To undo the command, select Presentation > Interpolate Invalid Points again.

To interpolate points with the status Disabled, proceed as follows:

1. Select Presentation > Interpolate Disabled Points.
2. To undo the command, select Presentation > Interpolate Disabled Points again.

☞ If interpolating points is active, then in ASCII export the interpolated data is saved. If you export as Universal File and ME'Scope or access via Polytec File Access, you will obtain the original data.

Change specification of vibrational direction

You can still retrospectively change the direction of the vibration in the presentation window. The vibrational direction shown in the legend is the one you selected in the dialog Acquisition Settings on the page Channels (refer to SECTION 6.2.2). Here you can select the direction of the vibration.

☞ You can not change the direction of the vibration for 3D data.

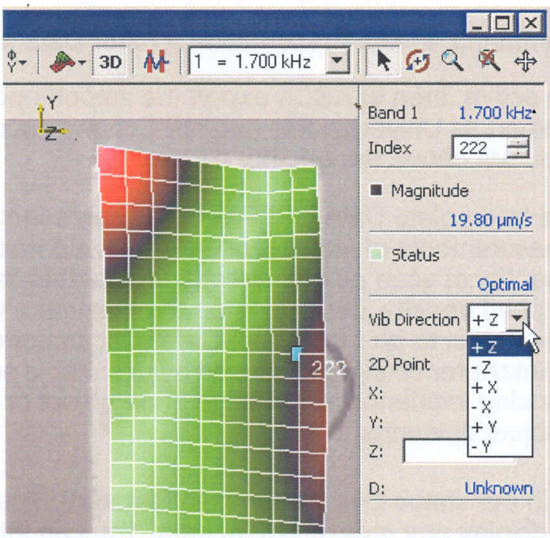


Figure 9.1: Selecting vibrational direction

With 2D geometries the direction of the vibration defines the scanning head coordinate system. Read up on this in SECTION 4.1.1 (Enter coordinates of axes) as well and in your theory manual.

9.2 Evaluating Sections of a Spectrum

You can evaluate sections of the measured spectrum. There are two ways to do so:

- Setting Cursors and Evaluating the Frequency Range (Cursor Mode), refer to SECTION 9.2.1
- Defining Frequency Bands (not in Time Mode), refer to SECTION 9.2.2

9.2.1 Setting Cursors and Evaluating the Frequency Range (Cursor Mode)

Requirement

With a single cursor you can evaluate spectra for scans which contain a complete spectrum. Scans without a complete spectrum are those,

- in which only frequency bands are saved (refer to SECTION 10.2.1),
- which were measured in the measurement mode FastScan or
- which were measured in the measurement mode Time.

For evaluation, proceed as follows:

1. Select the domain FFT.
2. From the list Frequency Band in the toolbar of the presentation window, select the entry Cursor.

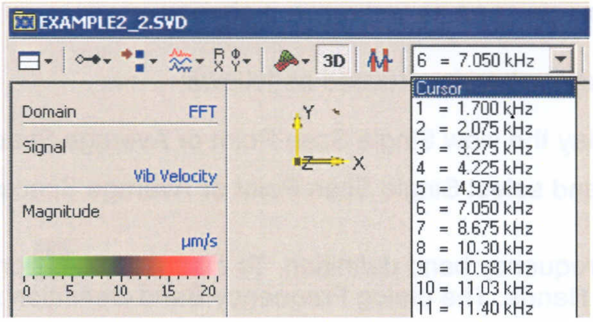


Figure 9.2: Selecting the entry Cursor

3. Set a single cursor in the analyzer as described in SECTION 8.2.3. The frequency and the magnitude at the current cursor position can be seen in the legend on the right. If the legend is not visible on the right in the analyzer, select Analyzer > Legend to display it. In the presentation window you will see the vibration position which the object under investigation takes at the selected frequency.
4. Drag the cursor while holding the left mouse button pressed to the left or right. This updates the data in the legend and the presentation window.

☞ If you do not set a cursor or delete the cursor you had set, you can also enter the required frequency directly in the legend of the presentation window.

9.2.2 Defining Frequency Bands (not in Time Mode)

To analyze the spectrum with the aid of frequency bands, start by entering the start and end frequencies of the frequency band in the frequency band definition. The software determines the peak frequency and the bandwidth of the frequency bands.

Requirement You can define frequency bands for scans,

- whose file is not write-protected and
- which contain a complete spectrum.

Scans without a complete spectrum are those

- in which only frequency bands are saved (refer to SECTION 10.2.1),
- which were measured in the measurement mode FastScan or
- which were measured in the measurement mode Time.

Save

The software saves the frequency band definition in the scan as soon as you save the scan. Read SECTION 10.2.1 on this. The software loads the frequency band definition when you open the scan again. You can also save the frequency band definition separately as an ASCII file and load it into several scans. See SECTION 10.2.5 and SECTION 10.1.3 on this.

☞ As a general rule, every change to a file is marked with an asterisk (*) in the file name as soon as you make a change.

Define

To define frequency bands, proceed as follows:

1. Either display the view Single Scan Point or Average Spectrum. To do so, click and select Single Scan Point or Average Spectrum.
2. Open the frequency band definition. To do so, click or select Setup > Frequency Bands. The dialog Frequency Band Definition appears.
3. Enter the start and end frequencies of the frequency bands as described below. You have two possibilities to do this: directly in the analyzer or in the dialog Frequency Band Definition. The software determines the peak frequencies of the frequency bands for the data set displayed in the view set.
4. You can change between different views or display other data sets without closing the frequency band definition. The software does not determine the peak frequencies again at that point. To determine the peak frequencies again, in the dialog Frequency Band Definition click .
5. If the software is to calculate 1/3 octave bands, then in the dialog Frequency Band Definition click .
6. When you have defined all frequency bands, close the frequency band definition. To do so, click again or select Setup > Frequency Bands. The software calculates the root mean square of the frequency bands and saves them in the scan.

Analyzer

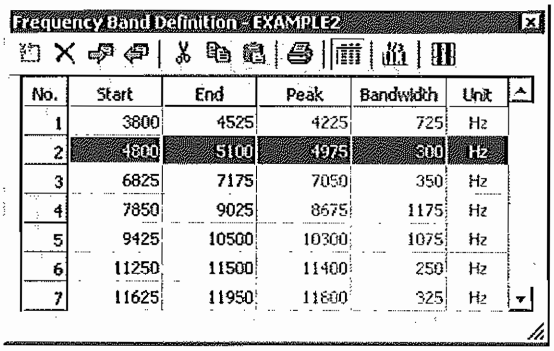
To enter start and end frequency of a frequency band directly in the analyzer, proceed as follows:

1. Click in the analyzer or select Analyzer > Show Bands.
2. Point at the diagram (not at the edge of the diagram).
3. Point at the start point of the required frequency band.
4. Press the mouse button and then drag right or left to the end point. The software displays the frequency band in color and enters it in the dialog Frequency Band Definition (see below).

Dialog

To enter start and end frequency of a frequency band in the dialog Frequency Band Definition, proceed as follows:

1. The dialog Frequency Band Definition consists of a toolbar and a table, the frequency band editor. If you can not see the table, display it. To do so, click in the toolbar of the frequency band definition.



No.	Start	End	Peak	Bandwidth	Unit
1	3800	4525	4225	725	Hz
2	4800	5100	4975	300	Hz
3	6825	7175	7050	350	Hz
4	7850	9025	8675	1175	Hz
5	9425	10500	10300	1075	Hz
6	11250	11500	11400	250	Hz
7	11625	11950	11800	325	Hz

Figure 9.3: Dialog Frequency Band Definition

2. In the toolbar, click . A new line is added to the bottom of the table.
3. Enter the start frequency in hertz. The start and end frequency must be on FFT lines. The software replaces the value entered by the next possible one.
4. Press Tab or click the corresponding cell in the column End.
5. Enter the end frequency in hertz.
6. Press Enter. The software enters the peak frequency and the bandwidth in the frequency band editor and displays the frequency band in the analyzer in color.

☞ If you have defined a new frequency band and close the frequency band definition, the new frequency band remains selected.

Select

To delete or copy frequency bands from the definition, you have to select them first. To do this, proceed as follows:

1. Click the frequency band in the analyzer or its line number in the frequency band editor.
2. To select further frequency bands, press the Control key and click the number of the line in the frequency band editor.
3. To select all frequency bands or to undo a selection, click the top left of the table.

Delete

To delete frequency bands from a definition, proceed as follows:

1. Select the frequency bands as described above.
2. Press the Delete key or in the dialog Frequency Band Definition click .

Copy

You can copy a frequency band definition via the clipboard into another scan. To do this, proceed as follows:

1. Select the frequency bands as described above.
2. In the dialog Frequency Band Definition click .
3. Close the current frequency band definition. To do so, in the presentation window click or select Setup > Frequency Bands.
4. Open the scan into which you want to copy the frequency bands.
5. Open the frequency band definition again. To do so, click or select Setup > Frequency Bands.
6. In the dialog Frequency Band Definition click .

Drag with the mouse

You can also apply frequency bands to another scan in the project browser by dragging with the mouse. To do so, proceed as follows:

1. Holding the left mouse button pressed, drag the entry Frequency Band from the project browser to the frequency band definition.

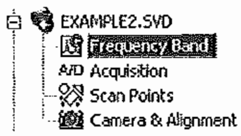


Figure 9.4: Entry Frequency Band in the project browser

2. Close the frequency band definition. A message box appears with the question whether the frequency bands are to be recalculated.
3. Click Yes.

☞ If you have defined a new frequency band and close the frequency band definition, the new frequency band remains selected.

9.3 Displaying Profile

You can display profiles of the data. To do this, you first draw profile sections on the object. You will see the profiles at the bottom in the analyzer. The software automatically saves the profile sections in the scan and loads them when you reopen the scan.

☞ If you want to draw profile section in a file (including a combined file) or want to display a profile, you first of all have to change over to 2D view.

Draw profile section

To draw a profile section on the object, proceed as follows:

1. Display the view Profile. To do so, click and select Profile in the context menu.
2. Display the view style Surface, Wireframe, Isolines or Scan Points. To do so, click and select the view style in the context menu.
3. Click .
4. Point at the object and click the start point of the profile section. The cursor becomes a .
5. Click as many other vertex points as you like. You can see the profile at the bottom in the analyzer.
6. To define the end point of the profile section, double-click.

Select profile sections

To edit profile sections, you have to select them first. To do this, proceed as follows:

1. Click .
2. Point at a profile section. The cursor becomes a .
3. Click. The software marks the vertex points of the profile section with white markers.
4. To select or deselect further profile sections, click them while holding the Control key pressed.
5. To select all profile sections, press the key combination Ctrl+A or select Edit > Select All.

Move profile sections

To move profile sections, proceed as follows:

1. Select the profile sections as described above.
2. Point at one of the lines (not at a vertex point). The cursor becomes a ✥.
3. Press the mouse button and drag in the direction required.

Move vertex points

You can change the shape of profile sections by moving the individual vertex points. To do this, proceed as follows:

1. Select a profile section as described above.
2. Point at a vertex point. The cursor becomes a ✥.
3. Press the mouse button and drag in the direction required.

Duplicate profile sections

To duplicate profile sections, proceed as follows:

1. Select the profile sections as described above.
2. Click or select Edit > Copy. The profile sections are copied onto the clipboard.
3. Click or select Edit > Paste.

☞ If you do not have selected a profile section, you can save data onto the clipboard with Edit > Copy as described in SECTION 10.2.11.

Delete profile sections

To delete profile sections, proceed as follows:

1. Select the profile sections as described above.
2. Press the Delete key or select Edit > Delete.

Animate

You can animate the profiles' vibrations. See SECTION 9.4 on this.

Undo and Redo

You can undo up to 50 operations and then redo them. To do so, click and or select Edit > Undo and Edit > Redo.

9.4 Animating Vibration

For you to be able to animate the measured vibration, during the scan either the signal has to be triggered (phase-related measurement) or a reference signal has to have been captured.

☞ In measurement mode Time you can not capture a reference signal.

How you animate vibrations in the different measurement modes, you read in:

- Measurement Mode FFT, Zoom-FFT, FastScan, MultiFrame, refer to SECTION 9.4.1
- Measurement Mode Time, refer to SECTION 9.4.2

9.4.1 Measurement Mode FFT, Zoom-FFT, FastScan, MultiFrame

If you have carried out a measurement in one of the above mentioned modes, you can set how many images per animation cycle are shown.

To animate a vibration, proceed as follows:

Preparation

1. Define frequency bands for the scan. See SECTION 9.2 on this.
2. Display the frequency band whose peak frequency you want to animate.
   Or:
   Go to Cursor Mode (refer to SECTION 9.2.1).
3. Display the FFT spectrum. To do so, click and select FFT in the context menu.
4. Display a complex signal.

☞ For complex signals, the display type Phase is available.

5. It is useful to display the 3D view. To do so, click 3D. You can animate in all view styles apart from the view style Status Points.
6. If in the list Select Frequency Band in the toolbar of the presentation window, you select the entry Cursor, then depending on the size of the file and the memory capacity of your PC, the following dialog may appear:

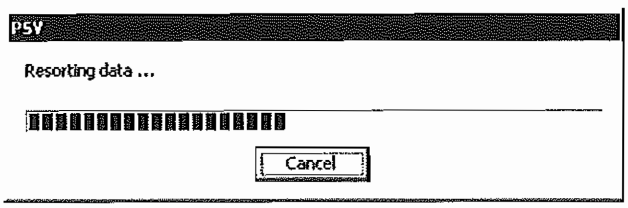


Figure 9.5: Resorting data

☞ If you do not have enough memory available, you will receive the message that you have to reduce the amount of data (refer to FIGURE 9.6 or FIGURE 9.7).

If you click Cancel here, you will be given the following message:

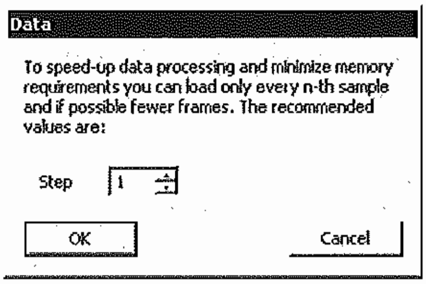


Figure 9.6: Dialog to reduce the amount of data (general)

It is recommended that you use the suggested value or enter a higher one. Thus you reduce the amount of data which is processed for animation, i.e. only every n-th sample point is used. Click OK. Subsequently the data will be resorted and you can start animation.

☞ If you set a smaller step size than the one suggested, the subsequent resorting of the data can take quite some time!

User defined data sets

If you are working with user defined data sets (see SECTION 8.6 on this as well), you can also evaluate these.

7. To do so, click and select the channel Usr in the context menu. It is also necessary to resort the data on this. If you abort this, here the dialog Data will also appear. In addition you can also limit the number of frames here to reduce the amount of data. The same recommendations as above also apply here.

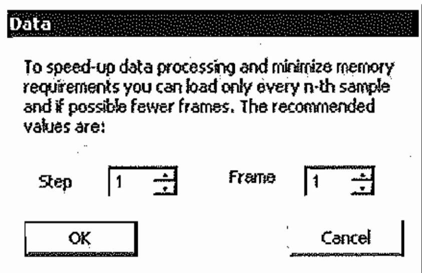


Figure 9.7: Dialog to reduce the amount of data (for user defined data sets)

Start

There are two ways of starting animation:

8. To start the animation in the active presentation window, click or select Animation > Start. The software shows the signal in the display type Instant Value and animates the vibration. You can see the instantaneous angle in the legend in the field Angle -120°. If the legend is not visible on the right of the object, select Presentation > Legend to display it.

or

To start animations simultaneously in all open presentation windows, select Animation > Start All.

Velocity

9. To increase or decrease the speed of the animations, select Animation > Increase Speed or Animation > Decrease Speed.

Stop

There are two ways of stopping animations:

10. To stop the animation in the active presentation window, click again or select Animation > Stop.

or

To stop all current animation, select Animation > Stop All.

Step forward, step backward

You can make animations run forwards or backwards image by image. To do so, click and or select Animation > Step Forward and Animation > Step Backward. You will see the next or previous animation frame respectively.

Frames per animation cycle

If you have carried out the measurement in FFT mode, you can set the number of frames per animation cycle in the dialog Preferences. To open the dialog, select Setup > Preferences. Then display the page Display.

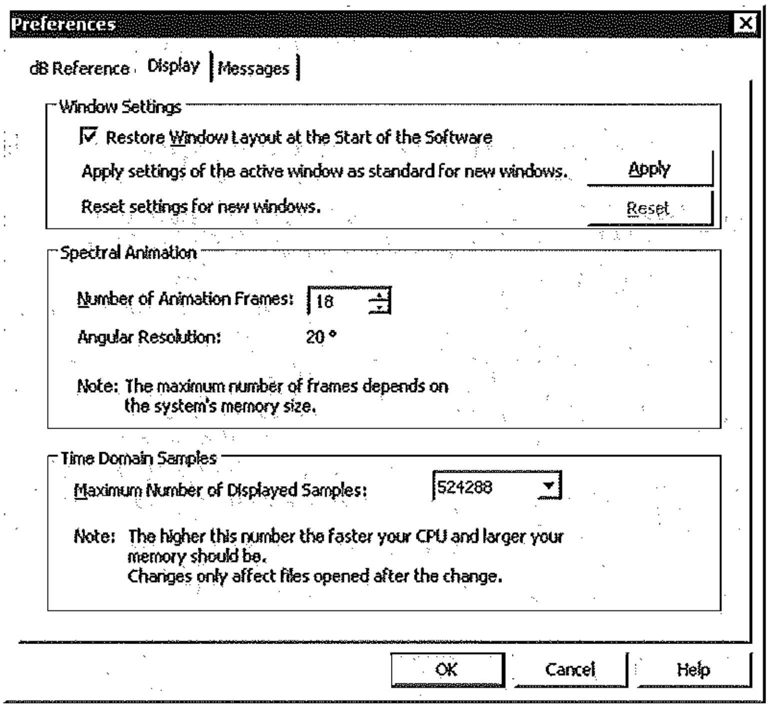


Figure 9.8: Page Display in the dialog Preferences

Number of Animation Frames: Here you enter how many frames per animation cycle you want to see. The minimum number is 8, the default setting is 18.

Angular Resolution: The software calculates the phase angle between the data of two frames and displays it here.

Maximum Number of Displayed Samples: Here you enter an upper limit for the number of samples to be shown simultaneously in the time domain.

Scale

You can change the degree of deflection in the animation with non-scalar data. To do so, you have three possibilities:

- To increase the deflection shown, click ↑] or select Presentation > Scale Up.
- To show the deflection with the default setting, click ↕] or select Presentation > Auto Scale.
- To weaken the deflection shown, click ↓] or select Presentation > Scale Down.

☞ Hold the shift key pressed during scaling and the scaling is immediately changed by a factor of 20.

Display vibrational directions (only 3D data)

Once you have made a measurement with the PSV-3D, you can show the vibrations of the object individually in x-, y- and z-direction. You can also combine displaying two vibrational directions with each other. To display and hide the vibrations in the various directions, click the icons X, Y and Z. If the icon is activated, then the vibration is being shown in the respective plane. If the icon is deactivated, then the vibration is not being shown in the respective plane.

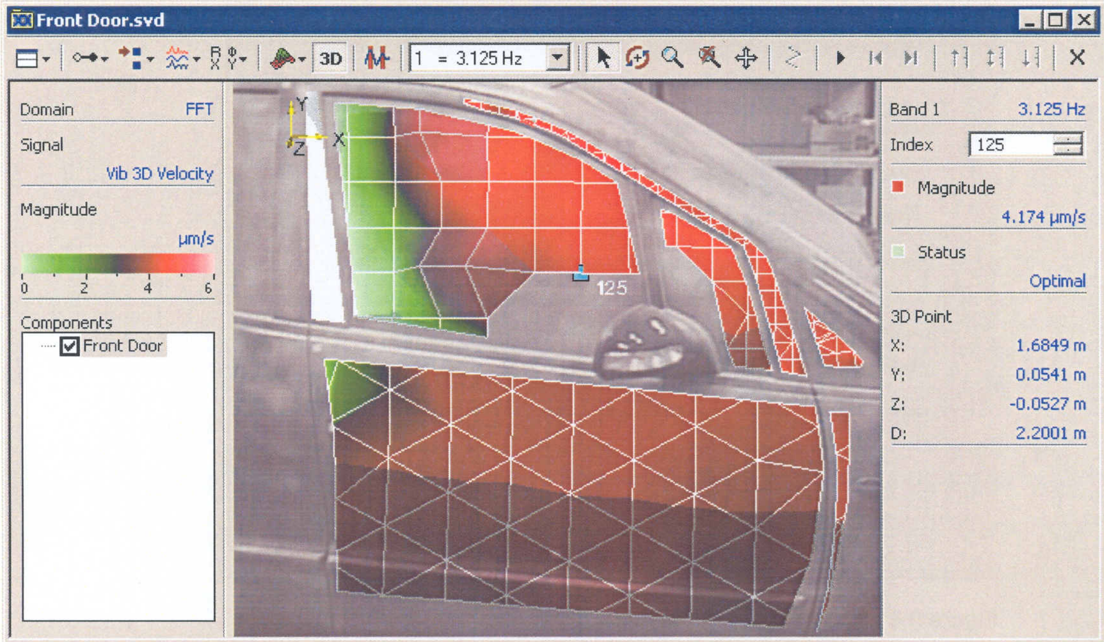


Figure 9.9: Presentation window in the view Object

Save

You can save animations in multimedia format *.avi. See SECTION 10.2.6 on this.

9.4.2 Measurement Mode Time

If you have carried out the measurement in Time mode, you will see the animation in the time domain. To animate a vibration, proceed as follows:

Preparation

1. Display the time domain. To do so, click and select Time in the context menu.

   Depending on the size of the scan file and capacity of your PC's memory, the following dialog may appear:

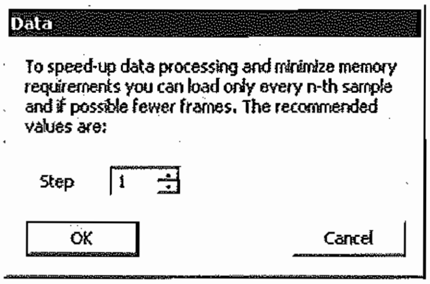


Figure 9.10: Dialog for reducing the time data step size

   It is recommended that you use the suggested value or enter a higher one. Click OK. This means that the time data is resorted and the z-axis scaled correspondingly and you can start the animation in time domain.

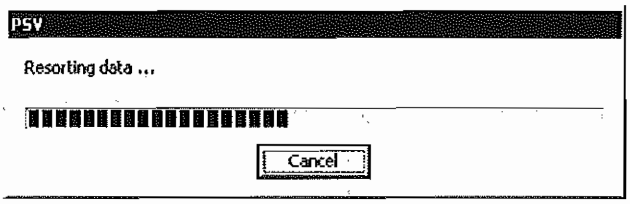


Figure 9.11: Resorting data

☞ If you set a smaller step size than the one suggested, the subsequent resorting of the time data can take quite some time!

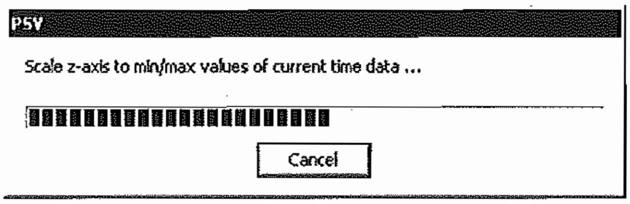


Figure 9.12: Scaling the z-axis

☞ If you click Cancel during resorting, the dialog Data to reduce the time data step size appears again (see above). To return to the RMS domain, click Cancel again.

2. It is useful to display the 3D view. To do so, click **3D**. You can animate in all view styles apart from the view style Status Points.

3. Select the section within the sample time in which the data is to be animated. There are two ways to do so:

   Enter the start and end time directly into the legend to the right of the presentation window. If the legend is not visible, select Presentation > Legend to display it.

or

   Open an analyzer. To do so, click and select Single Scan Point. Click and with a further mouse click, set the starting point directly in the diagram. (As initially the starting point is identical with the current point in time, it is marked by a red line.)
   Hold the mouse button pressed and drag it to the right. A second black line will appear which marks the end point. If the line is in the right place, release the mouse button.

Start

There are two ways of starting animation:

4. To start the animation in the active presentation window, click or select Animation > Start. You can see the defined time frame and the current status of the animation and also the step size in the legend.

or

   To start animations simultaneously in all open presentation windows, select Animation > Start All.

You can let the animation run forwards or backwards and stop it at any time, change its speed or save it as described in the following:

Velocity

5. To increase or decrease the speed of the animations, select Animation > Increase Speed or Animation > Decrease Speed.

Stop

There are two ways of stopping animations:

6. To stop the animation in the active presentation window, click again or select Animation > Stop.

or

   To stop all current animation, select Animation > Stop All.

Step forward, step backward

You can make animations run manually forwards or backwards. To do so, click ▶| and |◀ or select Animation > Step Forward and Animation > Step Backward. You will see the next or previous animation frame respectively.

Save

You can save animations in multimedia format *.avi. See SECTION 10.2.6 on this.

10 Managing Data

To manage your measurement data, the following functions are available:

You will find information on opening, loading and importing files, settings and data in SECTION 10.1.

You will find information on saving and exporting files, settings and data in SECTION 10.2.

10.1 Opening, Loading and Importing

The software can:

- Opening or Loading Files, refer to SECTION 10.1.1
- Opening Scans, Single Point Measurements and Signal Processor Documents, refer to SECTION 10.1.2
- Loading Frequency Band Definition, refer to SECTION 10.1.3
- Loading and Deleting Settings, refer to SECTION 10.1.4
- Importing Data in Universal File or ME'Scope Format, refer to SECTION 10.1.5

10.1.1 Opening or Loading Files

Open

The software can open the following files:

- Scans in the proprietary binary format Scan Data (*.svd), refer to SECTION 10.1.2
- Single point measurements in the proprietary binary format Single Point Data (*.pvd), refer to SECTION 10.1.2
- Signal processor files in the proprietary binary format Signal Processor Files (*.spd), refer to SECTION 10.1.2
- Frequency band definitions in the ASCII format, refer to SECTION 10.1.3

Load

The software can load or import the following files:

- Settings in the proprietary binary format Settings Files (*.set), refer to SECTION 10.1.4
- Measurement data in the format Universal Files (*.unv), (*.uff), (*.asc), refer to SECTION 10.1.5
- Measurement data in the format MEScope5 Project Files (*.vtprj) or MEScope Block Files (*.blk), refer to SECTION 10.1.5

File Information If you have opened a file you can display additional information that you saved with the file. To do so, click or select File > Info. You can also use the command Info in the project browser. See also SECTION 2.6.4 on this. The dialog File Information appears.

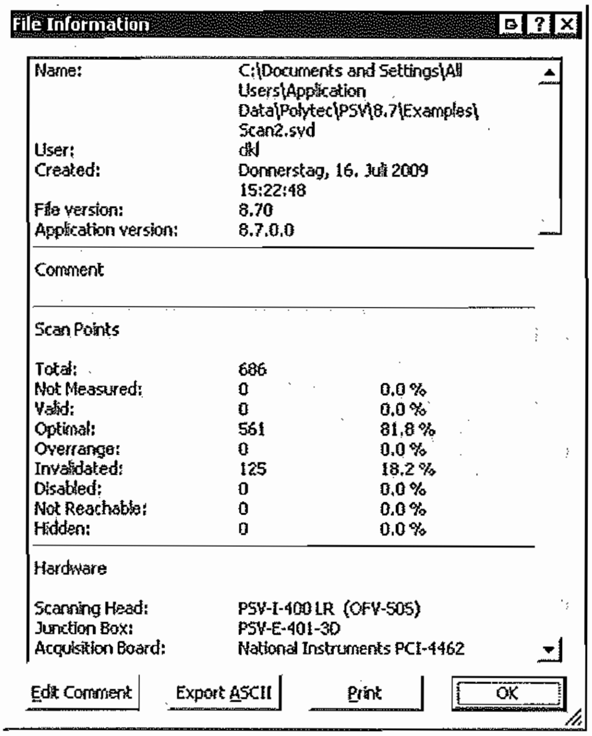


Figure 10.1: Dialog File Information

File Information: Here you see the file name with the complete file path, the user, the creation date, and with which software version the measurement was made.

Comment: Here you see comments on the measurement. You can complete the comment by clicking Comment at the bottom. The dialog Comment appears. You can now complete the text on the measurement and save it by clicking OK.

Scan Points: Here you see which scan status the scan points have gotten during the measurement.

Hardware: Here you see with which scanning head, junction box and data acquisition board the measurement was made.

General, Frequency, Sampling, Trigger, Channels, SE, etc. Here you see the measurement mode and the settings with which the measurement was made.

Vibrometer 1: With the UHF, here you see data about the controller, the sensor head and the Bragg cell frequency.

Export ASCII: You can export the file information as an ASCII file. To do so, click Export ASCII at the bottom. The dialog Save As appears. Here navigate to the saving location, enter the file name and click Save.

Printing: You can print out the file information. To do so, click Print. The dialog Print appears. Here you can select the printer and set up further print properties. To start the printing process, click OK.

10.1.2 Opening Scans, Single Point Measurements and Signal Processor Documents

In presentation mode you can open scans and single point measurements in the proprietary binary formats Scan Data (*.svd) and Single Point Data (*.pvd). There are two ways of doing this:

- Dialog Open
- List of most recent files in the menu File
- Project browser

You can also open the last scan measured if you change into presentation mode. To do this, follow the instructions in the software.

Open via dialog To open a scan or a single point measurement, proceed as follows:

1. Click or select File > Open. The dialog Open appears.

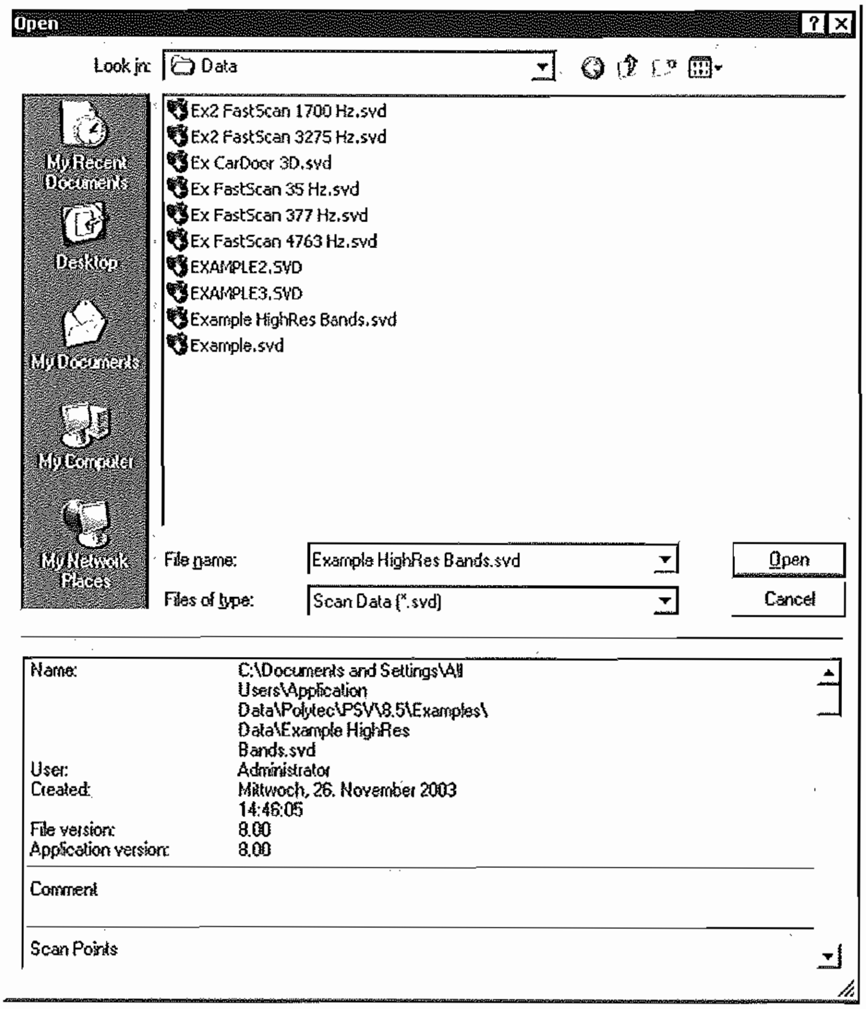


Figure 10.2: Dialog Open

2. Navigate to the saving location and select the file type and name. To make it easier to identify the files, look at meta-information at the bottom in the dialog – for example, the data acquisition board and the settings with which the data was measured.

3. Click Open. If you open a scan, a presentation window appears. If you open a single point measurement, an analyzer appears.

Open via file list In presentation mode, in the menu File at the bottom there is a list with up to nine files which you last opened. In the menu File at the bottom there is a list with up to nine files which you last opened.To open one of these files again, click it in the list.

Open via project browser You can use the project browser to open the files, see SECTION 2.6.4 under Open on this.

10.1.3 Loading Frequency Band Definition

In presentation mode, you can load frequency band definitions in ASCII format.

☞ When you load a frequency band definition, the existing one is overwritten.

To load a frequency band definition, proceed as follows:

1. Open the scan you want to load a frequency band definition for. See SECTION 10.1.2 on this.
2. Open the frequency band definition. To do so, click . The dialog Frequency Band Definition appears.
3. In the dialog Frequency Band Definition, click . The dialog Open appears.
4. Navigate to the saving location and select the file.
5. Click Open.
6. Close the frequency band definition. To do so, click again.

10.1.4 Loading and Deleting Settings

In acquisition mode, you can load settings from files in the proprietary binary format Settings Files (*.set) and from scans. You can only delete settings if they are saved in a setting file (*.set). You can not delete the settings of a scan.

☞ You will find information on saving the current settings in SECTION 10.2.7.

You can load the following information from setting files and scans:

- Frequency band definition (not possible from setting files)
- Settings for data acquisition in the dialog Acquisition Settings A/D (only possible for identical data acquisition boards)
- Scan point definition
- Settings of the optics (alignment, only PSV-400 and PSV-300: zoom and focus of the video camera)
- Window layout (not possible from scans)

☞ If problems occur when loading settings, a message appears which in detail shows what kind of settings could not be loaded. All other settings are loaded.

To load the settings, you have two options:

- Dialog Open
- Project browser

Load via dialog To load settings via the dialog, proceed as follows:

1. Click [icon] or select File > Load Settings. The dialog Open appears.

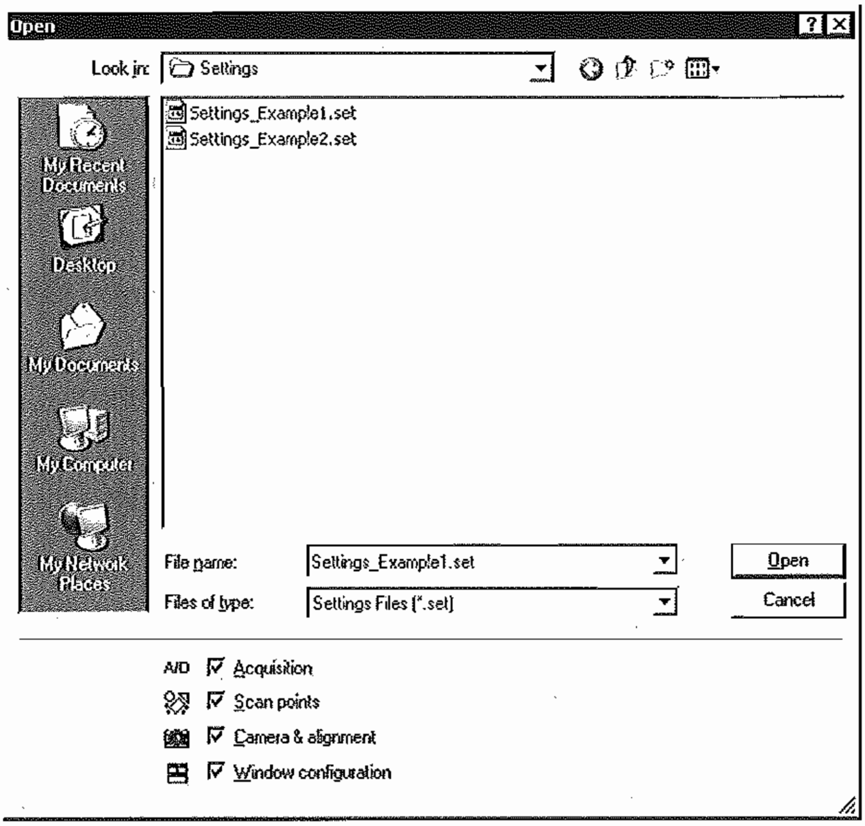


Figure 10.3: Dialog Open

2. Navigate to the saving location, select the file type and the file. At the bottom in the dialog, you can select which settings you want to load. To do so, click the corresponding check box.

☞ If you have the project browser displayed (refer to SECTION 2.6.4), you will then automatically be shown the directory marked there as saving location.

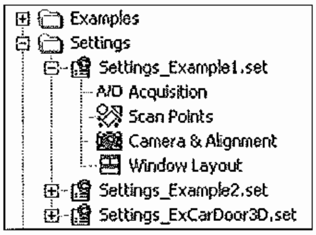
3. Click OK. A message box appears with the question whether you want to overwrite your settings until now. Click Yes. The selected settings will be loaded.

Load via project browser To load settings via the project browser, proceed as follows:

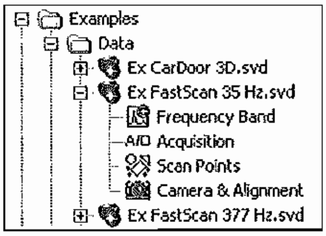
1. Open the project browser (refer to SECTION 2.6.4).

2. Open a directory which contains setting files or scans.

3. Click the plus sign (⊞) in front of the setting file (*.set), the scan (*.svd) or the single point measurement (*.pvd) which you want to load the settings from. You will see a list of settings which are saved in the file.



Settings in the setting file



Settings in the scan

Figure 10.4: List of saved settings

Load individual settings

4. If you only want to load certain settings from a file, mark them. To mark several settings at once, hold the control key pressed and click the respective settings.

5. Double-click the selected line(s).

   Or:

   Click the marked settings with the right mouse button and select Load in the context menu.

Load all settings

6. If you want to load all settings from a setting file, double-click the file name.

   Or:

   Click the file name with the right mouse button and select Load in the context menu.

7. A message box appears with the question whether you want to overwrite your settings until now. Click Yes.

Delete

To delete settings, proceed as follows:

☞ You can only delete settings if they are saved in a setting file (*.set). You can not delete the settings of a scan.

1. Open the project browser (refer toSECTION 2.6.4).

2. Click the plus sign (⊞) in front of the setting file (*.set), whose settings you want to delete. You will see a list of settings which are saved in the file (refer to FIGURE 10.4).

Delete individual settings

3. If you only want to delete certain settings from the setting file, mark them. To mark several settings at once, hold the control key pressed and click the respective settings.

4. Click the marked settings with the right mouse button and select Delete in the context menu.

Delete the setting file

5. If you want to delete the setting file, click the file name with the right mouse button and select Delete in the context menu.

10.1.5 Importing Data in Universal File or ME'Scope Format

You can import data in Universal File or ME'Scope format in presentation mode. This data is saved as user defined data sets and can then be analyzed. This thus enables you for example to import modal adaptations to the spectra from ME'Scope and to make comparisons with the original data in the software.

To import data in Universal File or ME'Scope format, proceed as follows:

1. Open the scan you want to import the data into. See SECTION 10.1.2 on this.

2. Select File > Import. The dialog Open appears.

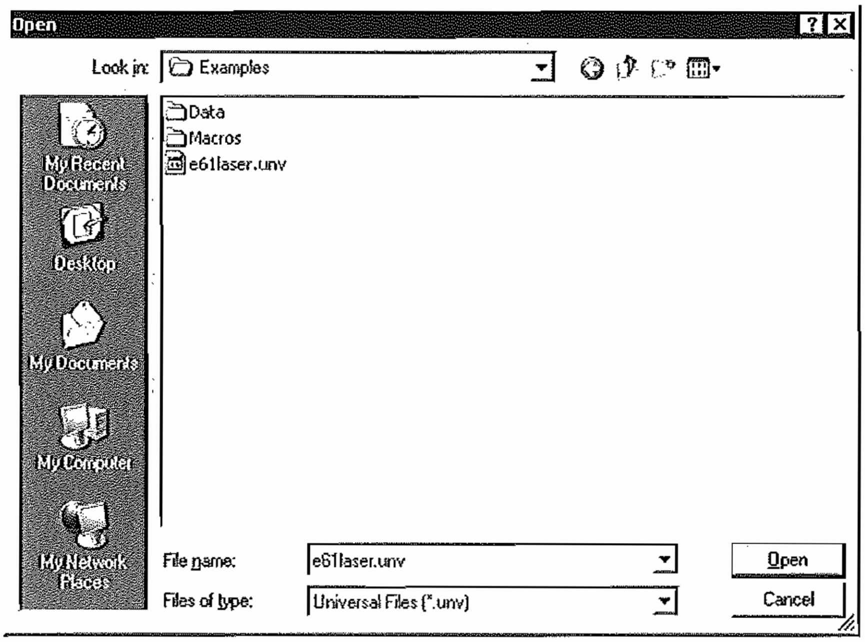


Figure 10.5: Dialog Open

3. Navigate to the saving location and select the file type and name.

☞ If you have the project browser displayed (refer to SECTION 2.6.4), you will then automatically be shown the directory marked there as saving location.

4. Click Open. The point data is imported and the dialog Properties of Signals to be Imported appears.

☞ If you import geometries from ME'Scope5 (new file extension *.vtprj), then ME'Scope5 is automatically started, the appropriate file opened, and then the data is imported. Thus, make sure that ME'Scope5 is installed on your PC.

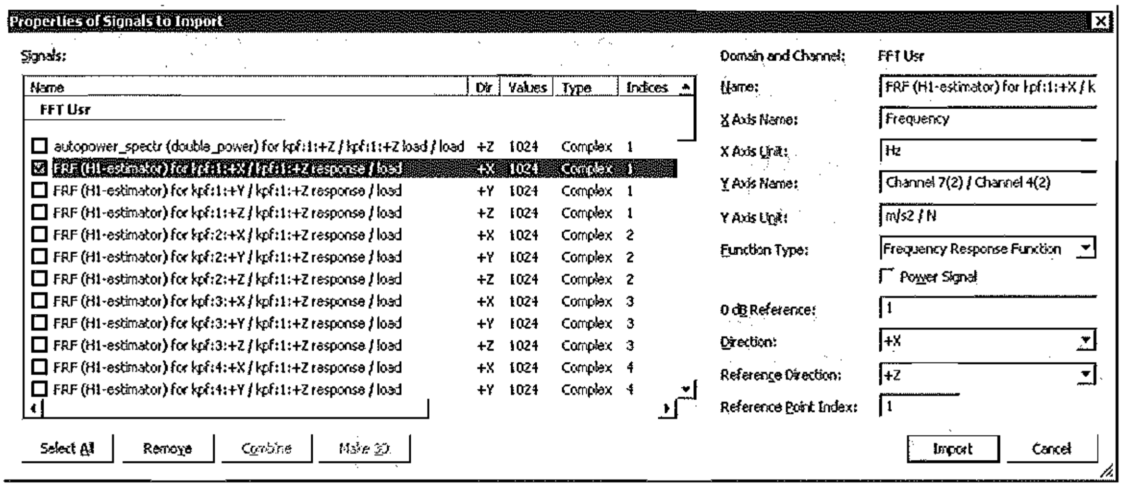


Figure 10.6: Dialog Properties of Signals to be Imported

5. Mark the signals which you want to import and if necessary set the parameters for import. You will find information on this in the following.

6. Click Import.

Signals

On the left you mark the signals which you want to import. To do so, you have to activate the corresponding box Name. If you want to import all signals. click Select All. If you want to remove superfluous signals to keep up the overview, mark them and click Remove.

Domain and channel

On the right your are shown the domain, channel and name of the signal and other properties. You can adapt these properties for every signal for import.

To set the properties of several user defined signals to the same value, proceed as follows:

1. Mark the corresponding signals in the list. To do so, hold the Control key pressed and click the signals.

2. Enter the desired common property on the right.

3. As soon as you change the signal selection or click OK the changes to the signals are accepted.

Combine

You can group signals with the same properties from different scan points (different indices). To do so, mark the corresponding signals by clicking the individual signals while holding the control key pressed or alternatively, while holding the shift key pressed, click the first and the last signal required.

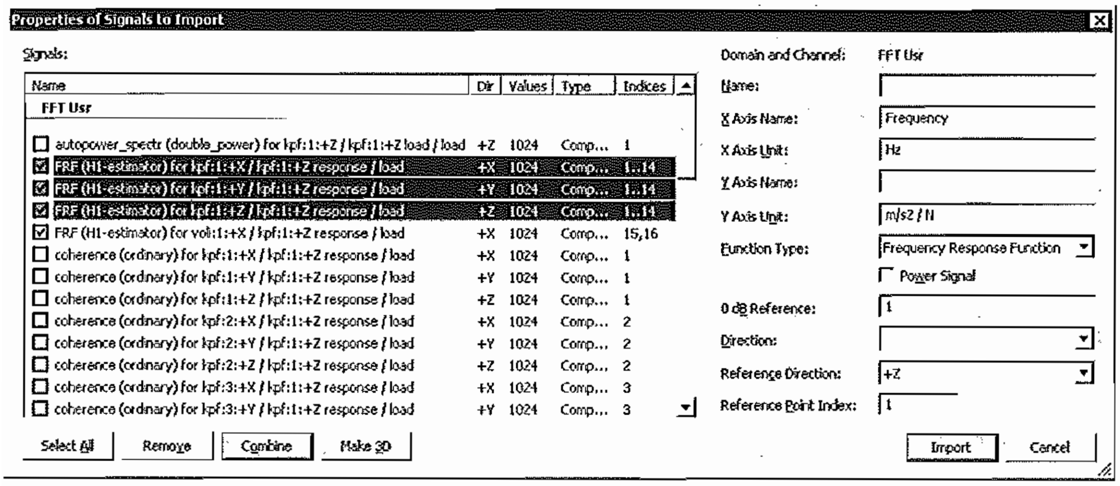


Figure 10.7: Combining signals

Then click Combine. The signals are combined and selected for import.

☞ If a combination is not possible you will receive a message which tells you which conditions need to be fulfilled.

Generate 3D signals

You can group together signals with the same properties and indices but with different directions into a 3D signal. To do so, mark the corresponding signals by clicking the individual signals while holding the control key pressed or alternatively, while holding the shift key pressed, click the first and the last signal required. Then click Generate 3D.

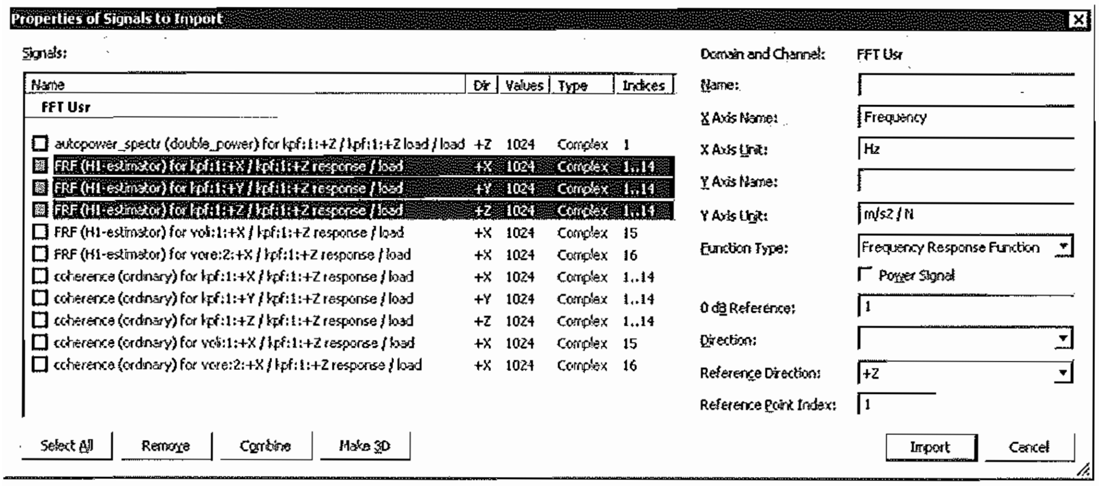


Figure 10.8: Generating 3D signals

The signals are grouped together to a 3D signal, are positioned under a separate headline and are marked for import.

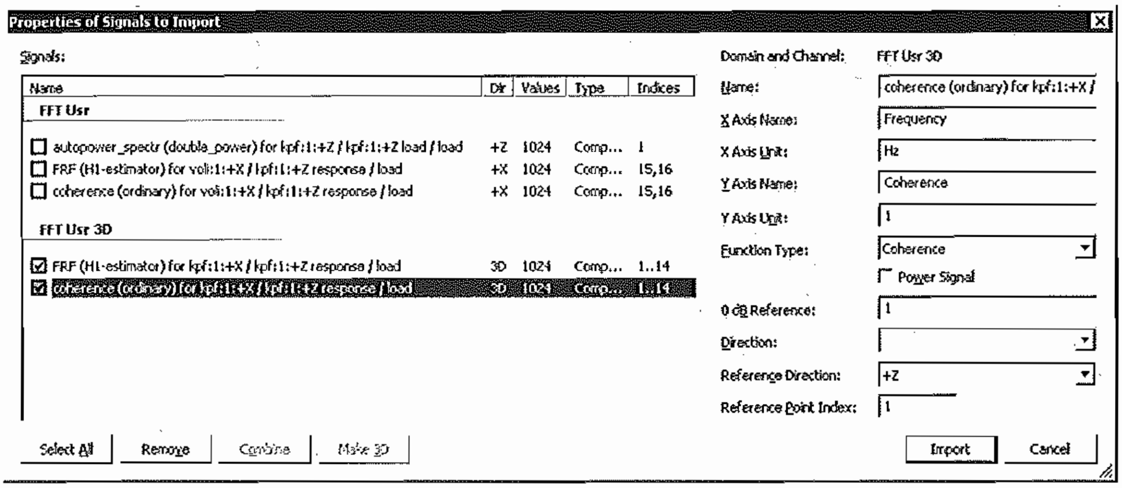


Figure 10.9: Generated 3D signal

☞ The separate positioning of the 3D signals only works in Windows® XP or Vista. In Windows® 2000 a new column Domain is inserted in which the 3D signals can be seen.

10.2 Saving and Exporting

The software provides the following ways of saving and exchanging data:

- Saving scans in the proprietary binary format Scan Data (*.svd), refer to SECTION 10.2.1
- Saving scans with frequency band data, but without point data in the proprietary binary format Scan Data (*.svd), refer to SECTION 10.2.1
- Saving scans with user defined data sets, but without frequency band data and original point data in the proprietary binary format Scan Data (*.svd), refer to SECTION 10.2.1
- Saving single point measurements and average spectrum in the proprietary binary format Single Point Data (*.pvd), refer to SECTION 10.2.2
- Exporting measurements in the format Universal File (*.uff, *.unv) as an option, refer to SECTION 10.2.3
- Exporting measurements in the format ME'Scope Files (*.str, *.blk, *.shp) as an option, refer to SECTION 10.2.4
- Saving frequency band definitions in the format ASCII Files (*.txt) or in the format Frequency Band Description (*.fbd), refer to SECTION 10.2.5
- Saving animations in the multimedia format AVI Files (*.avi), refer to SECTION 10.2.6
- Saving settings in the proprietary binary format Settings Files (*.set), refer to SECTION 10.2.7
- Exporting measurement data in the format ASCII Files (*.txt), refer to SECTION 10.2.8
- Exporting measurement data in the Wave Sound format Sound Files (*.wav), refer to SECTION 10.2.9
- Saving windows in different graphics formats, refer to SECTION 10.2.10
- Copying measurement data in ASCII format, signal processor data, graphics, and window settings onto the clipboard, refer to SECTION 10.2.11
- Saving recalculated scans as signal processor document in the format Signal Processor Data (*.spd), refer to SECTION 8.6.4

10.2.1 Saving Scans

Complete scan

When you start a scan, the software automatically creates a file for the scan and prompts you to save. See SECTION 7.2 on this. When scanning, the software saves the following data in proprietary binary format Scan Data *.svd:

- Settings (refer also to SECTION 10.2.7)
- Spectra at all completely measured scan points (single point spectra)
- Average spectrum of all scan points
- Root mean square of the magnitude over the entire bandwidth

Even if you abort a scan, the software has saved all scan points which had already been measured.

In presentation mode, you can define frequency bands for a scan (refer to SECTION 9.2) and draw profile sections (refer to SECTION 9.3). The software automatically saves the frequency band definitions and profile sections in the scan.

Frequency bands

In presentation mode, often only certain sections of the frequency range measured are of interest. For these sections you usually define frequency bands and then evaluate only those frequency bands. You can then save this scan without the single point spectra, as the frequency bands contain all relevant information. This means you can save a lot of disk space. The scan is then subject to certain limitations:

- You can not define any other frequency bands.
- The view Single Scan Point is not available.

Please note that the average spectrum saved corresponds to the spectrum created by removing invalidated single points (refer also to SECTION 9.1). In the generated file, the average spectrum remains unchanged when you set points to Valid or Invalidated because the single point spectra required for them are not existent.

To save a scan without single point spectra, proceed as follows:

1. Open the scan you want to save. See SECTION 10.1.2 on this.
2. Define the frequency bands which you want to evaluate. See SECTION 9.2 on this.
3. Select File > Save Bands. The dialog Save As appears.
4. Navigate to the saving location and enter the file name. The software suggests the file name scan name_b. However, you can also select another file name.

☞ If you have the project browser displayed (refer to SECTION 2.6.4), you will then automatically be shown the directory marked there as saving location.

5. Click OK.

10.2.2 Saving Single Point Measurement and Average Spectrum

In acquisition mode, you can save the measurement in the active analyzer in the proprietary binary format Single Point Data *.pvd. In presentation mode, you can save the single scan point or the average spectrum displayed from a scan. Please note that the average spectrum saved corresponds to the original data and not to the spectrum created by removing invalidated single points (refer also to SECTION 9.1). In doing so, the software saves the following data:

- Time signals
- Spectra
- Parameters for data acquisition and evaluation.

To save, proceed as follows:

1. Select File > Save Analyzer As. The dialog Save As appears.

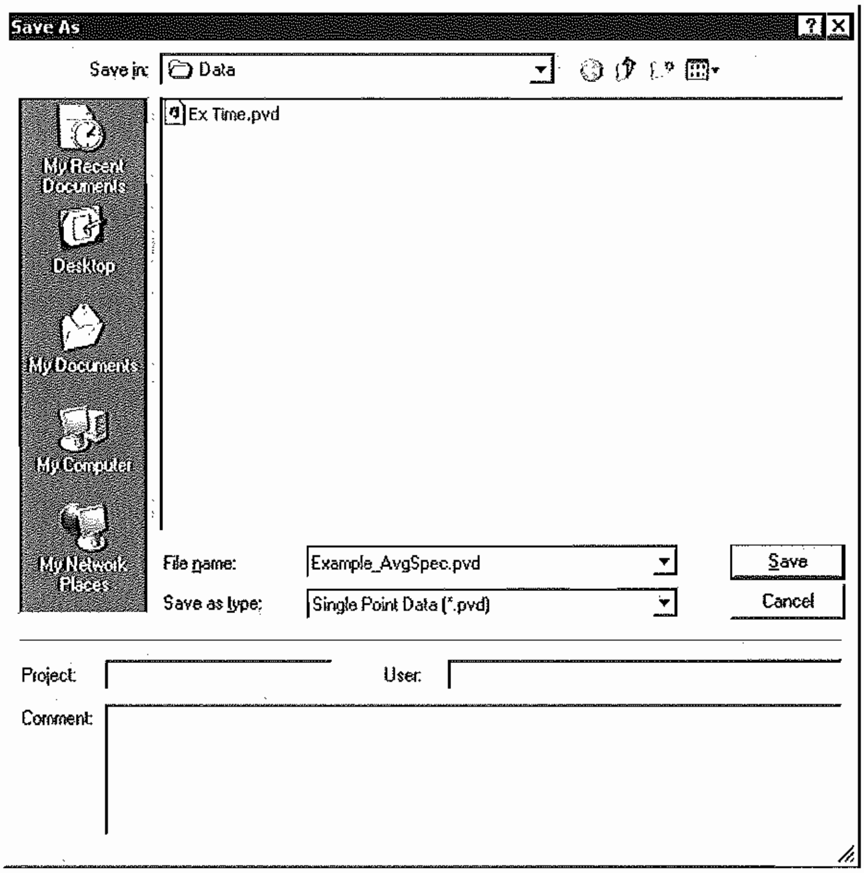


Figure 10.10:Dialog Save As

2. Navigate to the saving location and enter the file name.

☞ If you have the project browser displayed (refer to SECTION 2.6.4), you will then automatically be shown the directory marked there as saving location.

3. Click Save copy, if you want to keep the original file open for serial measurements. Thereby the window configuration is also retained. Otherwise, the original file is closed and you will see the analyzer in presentation mode.

4. At the bottom in the dialog you can enter meta-information to give the file more precise properties. This meta-information is part of the file properties which you can also view and edit in Explorer. You can also call up this information using the command Info in the project browser (refer toSECTION 2.6.4).

5. Click Save.

10.2.3 Exporting Universal File (as an Option)

In both acquisition and presentation mode, you can export data in Universal File format which is compatible with the modal analysis software from the companies SDRC (MTS), LMS and STAR and Vibrant (ME'Scope). To do this, you need the option Universal File Format.

☞ You can export Universal Files in acquisition mode, but not in APS mode.

Scan points with the status Not Measured, Overrange or Invalidated are not exported. Data evaluation with Presentation > Filter Data and Presentation > Interpolate Data does not have any effect on export, the measured data is exported. Only with option VDD: Measurements in measurement mode I/Q can not be exported as Universal Files.

Signals which have been gained from the original signals through integration and differentiation can be exported.

To export a Universal File, proceed as follows:

1. If you want to carry out a Universal File export in presentation mode, open the scan you want to export. See SECTION 10.1.2 on this.
2. Select File > Export > Universal File. The dialog Save As appears.

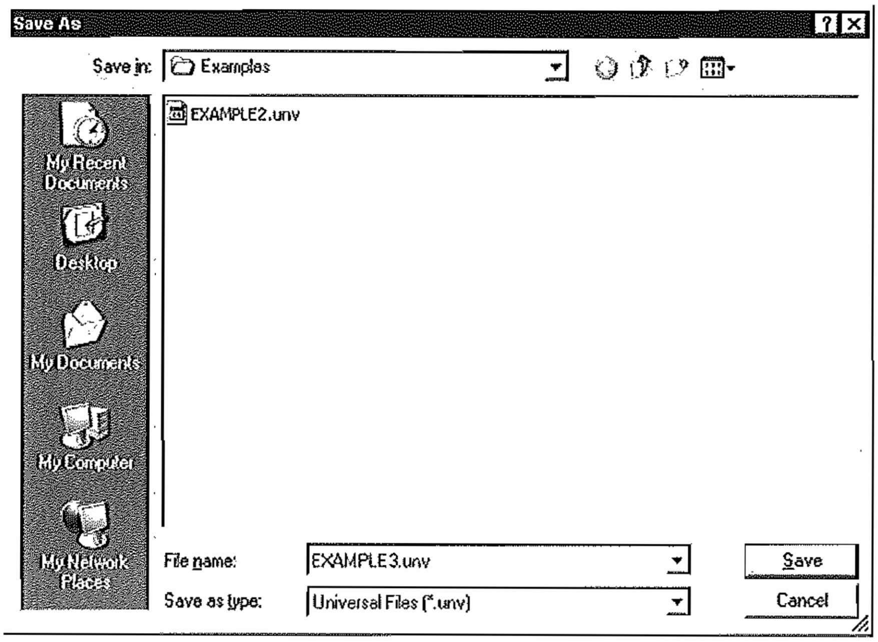


Figure 10.11:Dialog Save As

3. Navigate to the saving location and enter the file name.

☞ If you have the project browser displayed (refer to SECTION 2.6.4), you will then automatically be shown the directory marked there as saving location.

4. Click Save. The dialog Universal File Export appears.

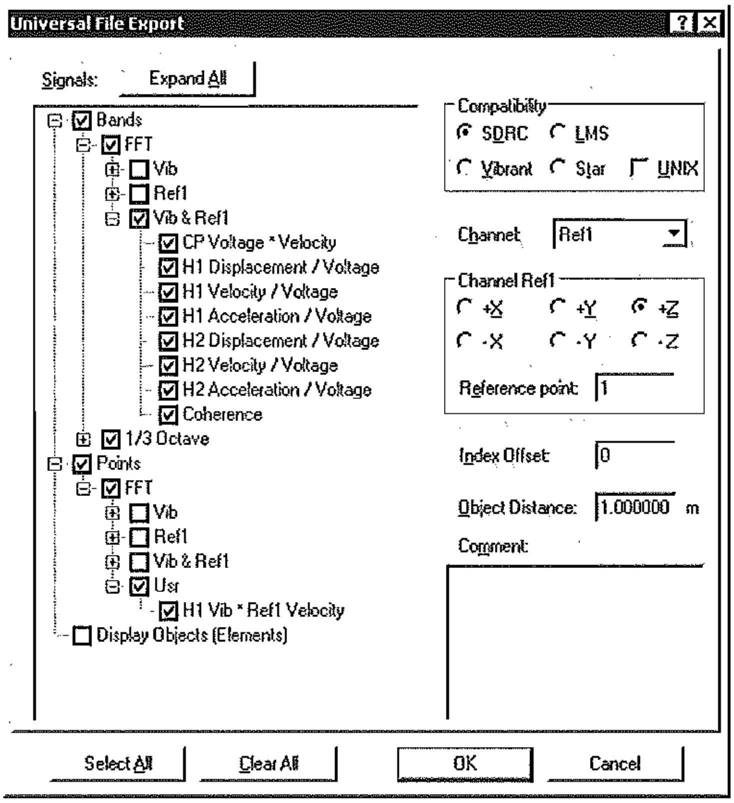


Figure 10.12:Dialog Universal File Export in presentation mode

5. If you export the data in acquisition mode, you are only offered displaying objects to choose from.

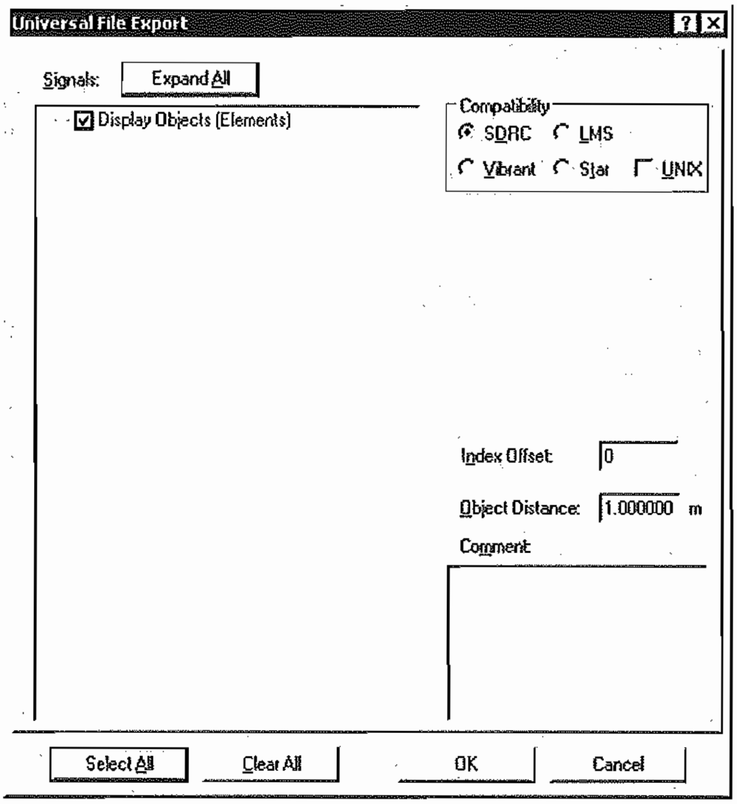


Figure 10.13:Dialog Universal File Export in acquisition mode

6. Mark the signals which you want to export and set the parameters for export. You will find information on this in the following.

7. Click OK.

You can correct the entries from a scan again for the current export and also enter new settings for files which already exist. The changes however do not have any effect on the scan saved.

Signals

On the left you mark the signals which you want to export. The selection depends on whether you are exporting in acquisition or in presentation mode, which signals you measured and whether frequency bands have been defined. If Display Objects (Elements) is ticked, then a graphic representation of the scan points and their connections is exported.

☞ If you want to export a Universal File in acquisition mode, here you can only select the display of the objects.

☞ You can export user defined data sets but not average spectra.

Parameters On the right you set the parameters for export.

☞ If you have defined geometry components (refer to SECTION 5.4.3), then only the component names for the data sets 82 and 58 will be taken into account for export.

Compatibility: Here you select the modal analysis software which the Universal File is to be compatible with. You will find a brief description of the data sets used in TABLE 10.1. For detailed information on this, see the manual for your modal analysis software.

Table 10.1: Data sets which are exported in the Universal File

Data set	Description	SDRC (MTS)	LMS	STAR	Vibrant
Header	General information, e.g. file name, date, comment	151	151	151	151
Units	Units of the signals and coordinates	164 Double precision	164 Double precision	164 Double precision	164 Double precision
Nodes (Geometry)	Coordinates of the scan points	2411 Double precision	2411 Double precision	15 Single precision	2411 Double precision
Elements (Trace Lines)	Graphic representation of the scan points and their connections	2412+82 Integer	82 Integer	82 Integer	2412+82 Integer
Frequency bands	A data set for every frequency band and every signal	55 Single precision	55 Single precision	55 Single precision	55 Single precision
Scan points	A data set for every signal and every scan point	58 Single precision	58 Single precision	58 Single precision	58 Single precision

UNIX: Tick the box if you carry out modal analysis under UNIX. Text lines will then be ended with a line feed to be UNIX compatible. Special characters in the comment – for example, German umlauts – are not adapted to UNIX.

Channel: Here you select the channel for which you want to see or change the direction of the vibration or the reference excitation.

Channel <Name>: Here you can see the direction of the vibration or the reference excitation for the selected channel (e.g. Ref3) and change it if necessary.

☞ It is not possible to specify the vibrational direction for the channel Vibrometer 3D.

Reference Point: If you have selected a reference channel and have measured the reference signal at one of the scan points, then you can enter the index of this reference point here.

☞ Please pay attention that the settings for the vibrational direction and the reference point do not have any effect on exporting user defined signals (channel Usr or Usr X, Usr Y, Usr Z). We recommend before exporting, that you check and, if necessary, change the properties of the user defined signals as described in SECTION 8.6.2.

Index Offset: Here you can enter an offset which the software adds to the indices of the scan points. This helps you to avoid an index being allocated more than once if you want to evaluate several scans at the same time.

Object Distance: Here you enter the stand-off distance in meters, measured from the front of the scanning head. In proprietary file format, the coordinates of the scan points are saved as angles, in the Universal File however in cartesian coordinates. Thus the stand-off distance is required for the conversion. For measurements with the close-up unit PSV-A-410 or OFV-056-C, you have to add 41 millimeters to the stand-off distance. This corresponds to the optical path length within the close-up unit. As a preset, the software shows the distance here which you have given in the legend in the element 2D Point (refer toSECTION 4.1). You can correct this distance here again, however this does not have any effect on the distance saved in the scan.

☞ This field does not appear for 3D geometries.

Comment: Here you can enter a comment up to 80 characters long.

10.2.4 Exporting ME'Scope (as an Option)

In both the acquisition and also presentation mode, you can export files in ME'Scope format. To do this, you need the option ME'Scope.

In acquisition mode, you can export the object geometry so that you can makes further use of it in other applications for example. You can export scans in presentation mode. Export will provide up to three files with the following data:

- Single points in the format *.blk (block)
- Frequency bands in the format *.shp (shape)
- Geometry in the format *.str (structure)

Scan points with the status Not Measured, Overrange or Invalidated are not exported. Data evaluation with Presentation > Filter Data and Presentation > Interpolate Data does not have any effect on export, the measured data is exported. Only with option VDD: Measurements in measurement mode I/Q can not be exported as ME'Scope.

To export to ME'Scope, proceed as follows:

1. If you want to carry out an ME'Scope export in presentation mode, open the scan you want to export. See SECTION 10.1.2 on this.

2. Select File > Export > ME'Scope. The dialog Save As appears.

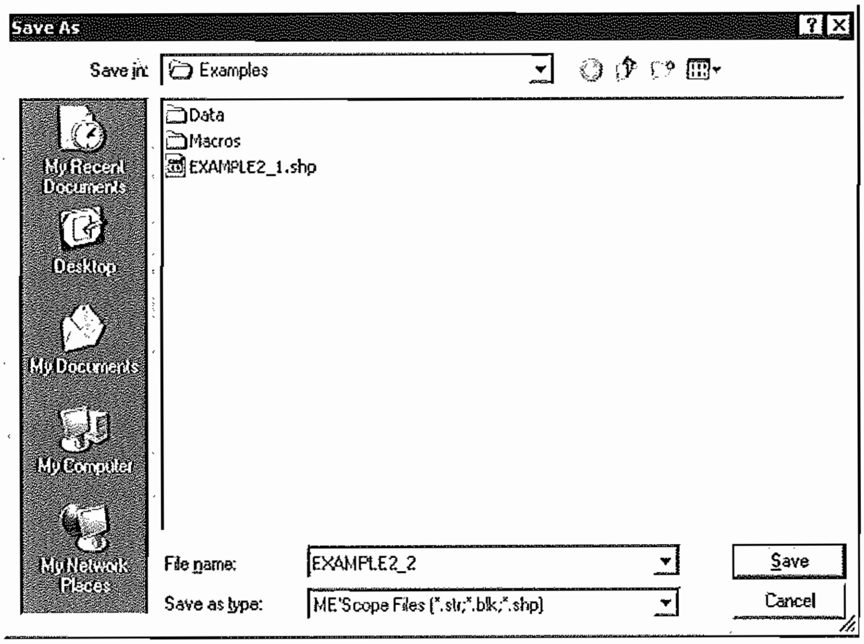


Figure 10.14:Dialog Save As

3. Navigate to the saving location and enter the file name.

☞ If you have the project browser displayed (refer to SECTION 2.6.4), you will then automatically be shown the directory marked there as saving location.

4. Click Save. The dialog ME'Scope Export appears.

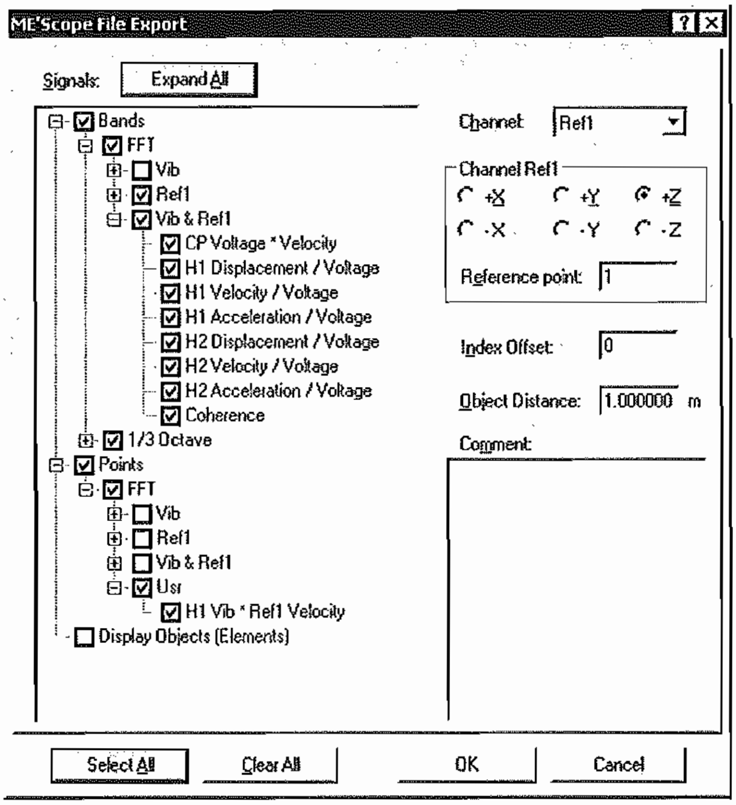


Figure 10.15:Dialog ME'Scope Export in presentation mode

5. If you export the data in acquisition mode, you are only offered displaying objects to choose from.

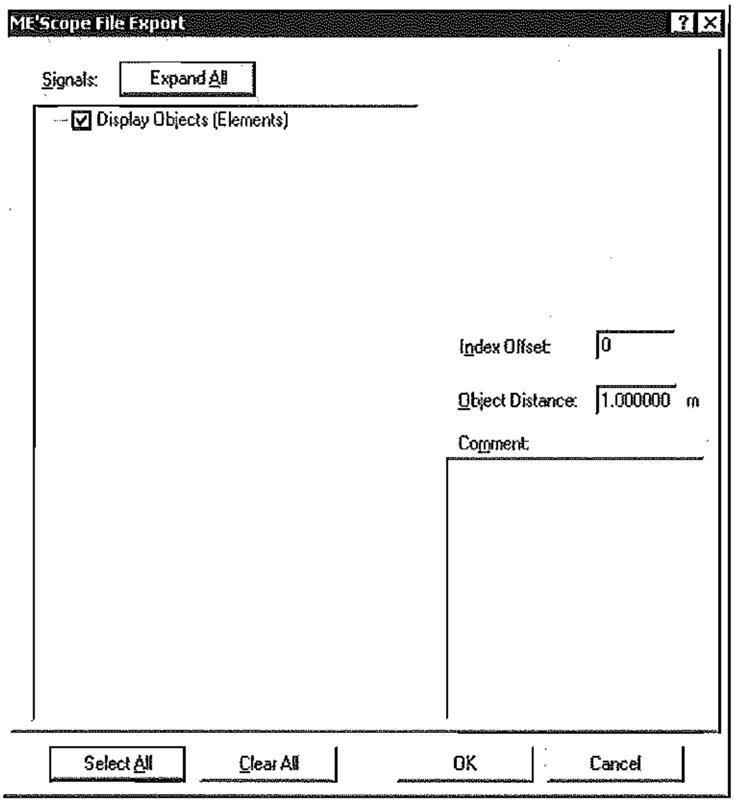


Figure 10.16:Dialog ME'Scope Export in acquisition mode

6. Mark the data which you want to export and set the parameters for export. You will find information on this in the following.

☞ Signals with different x-axes, e.g. signals of the domains Time and FFT, can not be exported together. Export these signals individually one after the other.

7. Click OK.

You can correct the entries from the scan again for the current export and also enter new settings for files which already exist. The changes however do not have any effect on the scan saved.

Signals

On the left you mark the signals which you want to export. The selection depends on whether you are exporting in acquisition or in presentation mode, which signals you measured and whether frequency bands have been defined. If Display Objects (Elements) is ticked, then a graphic representation of the scan points and their connections is exported.

☞ If you want to export data in ME'Scope format in acquisition mode, here you can only select the display of the objects.

☞ You can export user defined data sets but not average spectra.

Parameters

On the right you set the parameters for export.

Channel: Here you select the channel for which you want to see or change the direction of the vibration or the reference excitation.

Channel <Name>: Here you can see the direction of the vibration or the reference excitation for the selected channel and change it if necessary.

☞ It is not possible to specify the vibrational direction for the channel Vibrometer 3D.

Reference Point: If you have selected a reference channel and have measured the reference signal at one of the scan points, then you can enter the index of this reference point here.

☞ Please pay attention that the settings for the vibrational direction and the reference point do not have any effect on exporting user defined signals (channel Usr or Usr X, Usr Y, Usr Z). We recommend before exporting, that you check and, if necessary, change the properties of the user defined signals as described in SECTION 8.6.2.

Index Offset: Here you can enter an offset which the software adds to the indices of the scan points. This helps you to avoid an index being allocated more than once if you want to evaluate several scans at the same time.

Object Distance: Here you enter the stand-off distance in meters, measured from the front of the scanning head. In proprietary file format, the coordinates of the scan points are saved as angles, in ME'Scope format however, as cartesian coordinates. Thus the stand-off distance is required for the conversion. For measurements with the close-up unit PSV-A-410 or OFV-056-C, you have to add 41 millimeters to the stand-off distance. This corresponds to the optical path length within the close-up unit. As a preset, the software shows the distance here which you have given in the legend in the element 2D Point (refer toSECTION 4.1). You can correct this distance here again, however this does not have any effect on the distance saved in the scan.

☞ This field does not appear for 3D geometries.

Comment: Here you can enter a comment up to 255 characters long.

10.2.5 Saving Frequency Band Definitions

In presentation mode, you can save the current frequency band definition in the ASCII format or as Frequency Band Description. To do so, proceed as follows:

1. Open the frequency band definition. To do so, click . The dialog Frequency Band Definition appears.
2. In the dialog Frequency Band Definition, click . The dialog Save As appears.
3. Navigate to the saving location, enter the file name and select the file type Frequency Band Description (*.fbd) or ASCII Files (*.txt).

☞ If you have the project browser displayed (refer to SECTION 2.6.4), you will then automatically be shown the directory marked there as saving location.

4. Click Save.
5. Close the frequency band definition. To do so, click again.

10.2.6 Saving Animations

In presentation mode, you can save animations in the multimedia format AVI Files (*.avi). You will find information on animations in SECTION 9.4.

To save an animation, proceed as follows:

1. Open the scan you want to save an animation for. See SECTION 10.1.2 on this.
2. Set up your animation as described in SECTION 9.4.1 or SECTION 9.4.2.
3. Select File > Save Animation. The dialog Save As appears.

☞ If the presentation window contains an analyzer, you can select whether you would like to save an animation from top graphics, the bottom graphics or both.

4. Navigate to the saving location and enter the file name.

☞ If you have the project browser displayed (refer to SECTION 2.6.4), you will then automatically be shown the directory marked there as saving location.

5. Click Save.

10.2.7 Saving Settings

In acquisition mode, you can save the current settings in the proprietary binary format Settings Files (*.set). A setting file contains:

- Settings for data acquisition in the dialog Acquisition Settings A/D
- Scan point definition
- Settings of the optics (alignment, only PSV-400 and PSV-300: zoom and focus of the video camera)
- Window layout

To save settings, proceed as follows:

1. Click or select File > Save Current Settings As. The dialog Save As appears.

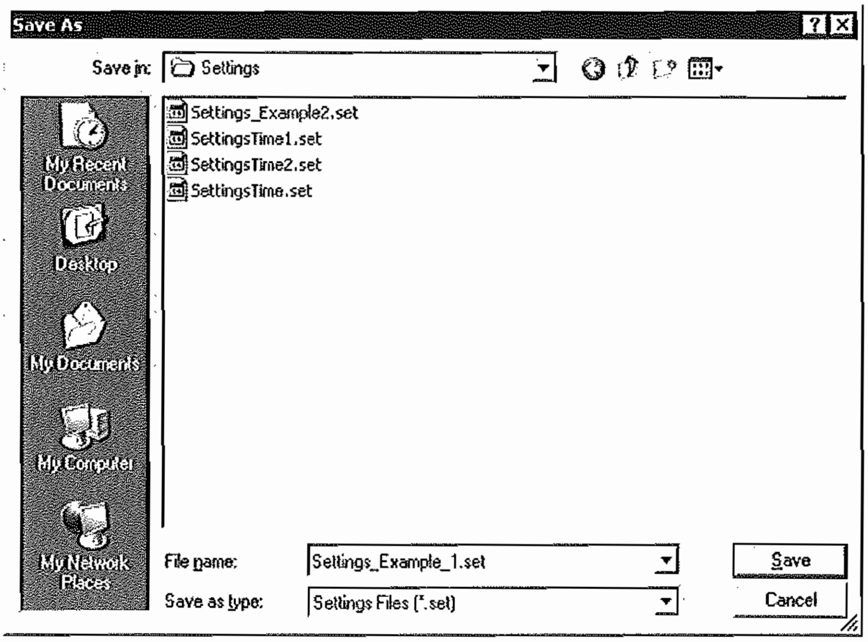


Figure 10.17:Dialog Save As

2. Navigate to the saving location and enter a file name.

☞ If you have the project browser displayed (refer to SECTION 2.6.4), you will then automatically be shown the directory marked there as saving location.

3. Click OK. All current settings are saved in the file.

10.2.8 Exporting Measurement Data in ASCII Format

You can export the data in the active analyzer or presentation window as an ASCII file. The coordinate system for ASCII export depends on whether you want to export 3D or 2D geometries. With 3D geometries always the complete x-, y-, z-coordinates are exported. With 2D geometries the coordinate system depends on whether you have entered the distance Z of the object in the element 2D Point in the scanning head control (refer to SECTION 4.1.1, Enter coordinates of axes). If this is the case, then also the complete x-, y-, z-coordinates are exported. Depending on the vibrational direction of the channel the coordinate in vibrational direction is set to 0. If no distance is entered, the coordinate system for ASCII export corresponds to the coordinate system of the live video image which you set the scan points on. The upper left corner in the coordinate system of the live video image is defined as u=0, v=0, the bottom right corner as u=4/3, v=1.

To calculate the angles of the scanner mirrors from the coordinates, you will need the information from the 2D or 3D alignment respectively. You will get this from Polytec File Access.

☞ In principle, always during export in ASCII format only the data is exported which has been displayed in the presentation window. If you have hidden components, this data will not be exported. If you have evaluated data (Filter Data or Interpolate Data), the evaluated data is exported.

To export the measurement data in ASCII format, proceed as follows:

1. Select File > Export > ASCII. The dialog Save As appears.

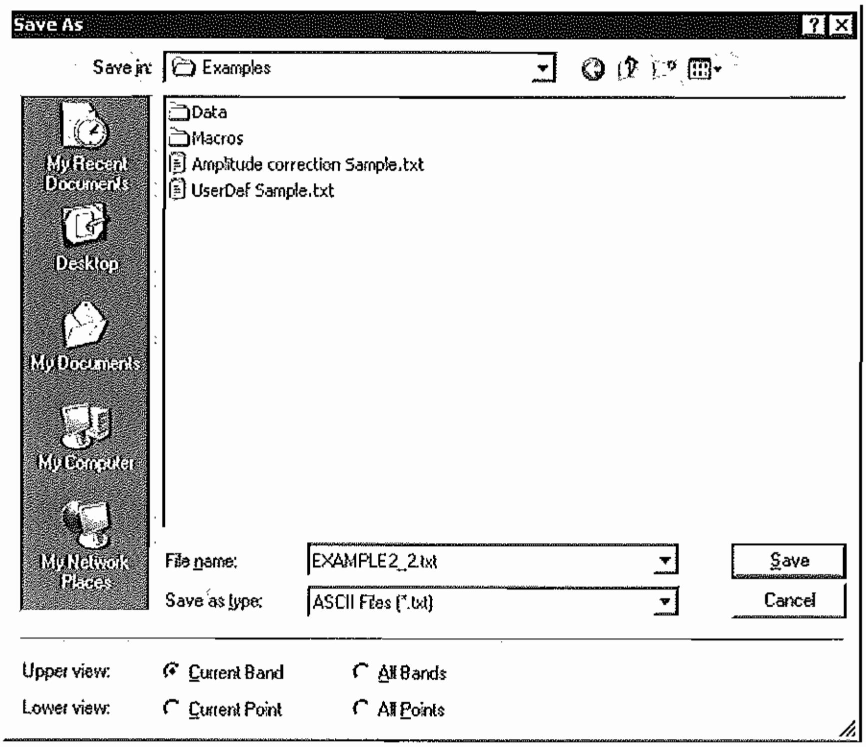


Figure 10.18:Dialog Save As

2. Navigate to the saving location, enter the file name and select the file extension.

☞ If you have the project browser displayed (refer to SECTION 2.6.4), you will then automatically be shown the directory marked there as saving location.

3. If you are exporting in presentation mode, you will see a selection at the bottom of the dialog. Select which data you want to export from the upper view or the lower view. You can export different data consecutively several times.

☞ If you are exporting all bands or all points, then a file is generated for every frequency band or every scan point.

4. Click Save.

10.2.9 Exporting Measurement Data in the Wave Sound Format

You can export data (time signals and spectra) in the active analyzer or presentation window as a file in the Wave Sound format Sound Files (*.wav). During exporting spectra, an inverse FFT is calculated on this. Make sure that for this purpose you will need a valid phase and "Rectangle" as the window function, so that you will receive the expected results.

☞ Therefore, we recommend exporting spectra in the Wave Sound format only when you have a complex signal for the measurement, and you have used a trigger and the window function "Rectangle".

To export in the Wave Sound format, you proceed as follows:

1. Select File > Export > Wave Sound. The dialog Save As appears.

2. Navigate to the saving location, enter the file name and select the file extension.

☞ If you have the project browser displayed (refer to SECTION 2.6.4), you will then automatically be shown the directory marked there as saving location.

3. Click Save.

10.2.10 Saving Graphics

You can save the active window in different graphics formats. The title bar and the frame are not saved. The live video image is saved without scan points.

To save, proceed as follows:

1. Select File > Save Graphics. The dialog Save As appears.

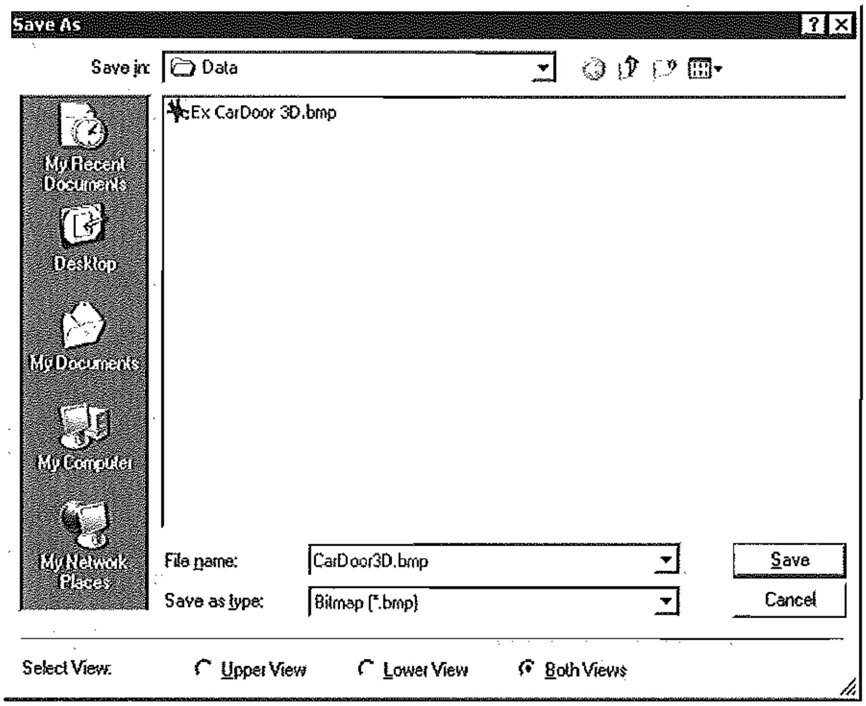


Figure 10.19:Dialog Save As

2. Navigate to the saving location, enter the file name and select the file type.

☞ If you have the project browser displayed (refer to SECTION 2.6.4), you will then automatically be shown the directory marked there as saving location.

3. If you are saving the graphics from presentation mode in the view Single Scan Point, Average Spectrum or Profile, then at the bottom of the dialog you see the field Select View. Select whether you want to save the upper, the lower or both graphics.

4. Click Save.

10.2.11 Copying Data onto the Clipboard

You can copy data onto the clipboard from the active window as graphics, as signal processor data or in ASCII format. Furthermore, you can copy the window settings onto the clipboard. If you select the graphics, then the title bar and the frame are not copied. The live video image is copied as graphics without scan points.

☞ Depending on the window selection or the view, you are offered a more or less comprehensive dialog.

To copy onto the clipboard, proceed as follows:

1. Activate the required window or the required view. To do so, click it.

2. Click  or select Edit > Copy. The dialog Copy appears.

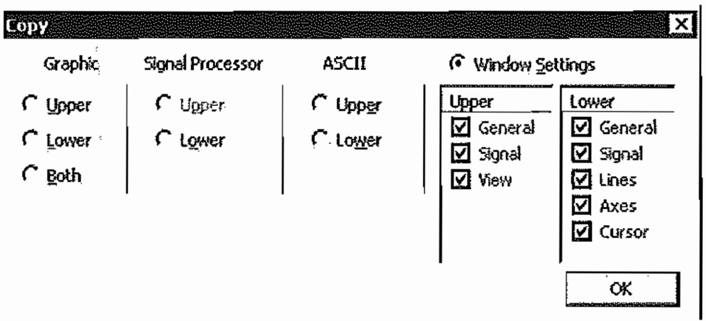


Figure 10.20:Dialog Copy

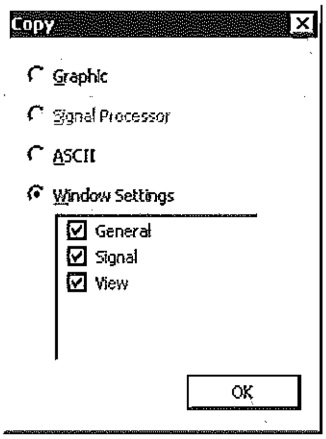
3. Select the data you want to copy onto the clipboard.

☞ When copying please pay attention, if you are in profile view, that you do not have selected profile lines. Otherwise these profile lines will be copied onto the clipboard.

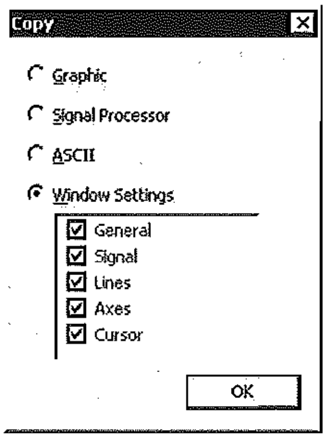
4. Click OK.

You can now paste the data from the clipboard into other applications.

You can also purposefully click a certain part of the window with the right mouse button and select Copy in the context menu. The dialog Copy appears.



Object view



analyzer

Figure 10.21:Dialog Copy

Select the data you want to copy onto the clipboard and click OK.

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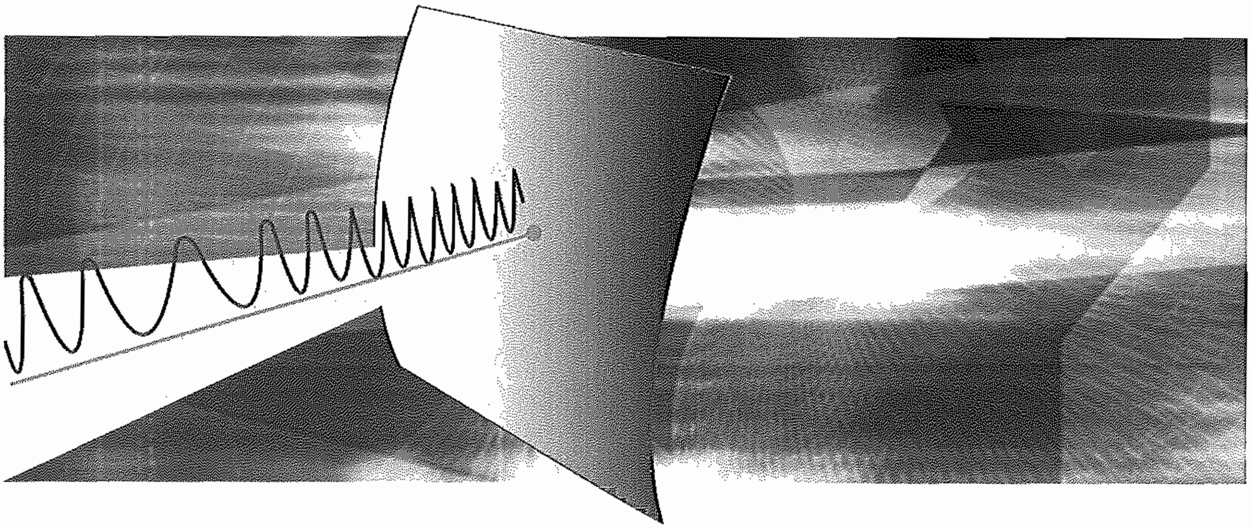
Theory Manual

Polytec Scanning Vibrometer



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Trademarks

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Appendix A: Introduction to Complex Numbers

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1 Introduction

Polytec's Scanning Vibrometers measure and analyze vibrations. If you are familiar with the theoretical background of signal processing and analysis, you can use the data acquisition system more efficiently. For further details refer to the specialist literature.

This manual explains

- how harmonic vibrations are described,
- how a time signal is transformed into a frequency spectrum by means of Fourier transformation,
- how alias rejection works,
- the effects of window functions,
- the effects of averaging,
- the calculation of frequency response and coherence,
- the choice of the appropriate excitation signal,
- the advantages of multiple reference analysis (MIMO),
- how to use digital filters to condition time signals,
- the theoretical background for PC-based digital demodulation (VDD)
- how to optimize the measurement setup for the PSV,
- how to work with 3D geometries and
- the introduction to complex numbers.

2 Description of Harmonic Vibrations

Vibrations can be described with trigonometric functions or complex numbers. Based on the special case of harmonic vibrations, the following describes the basics as needed for the following chapters.

2.1 Harmonic Vibrations described with Trigonometric Functions

Harmonic vibrations have a sinusoidal shape. A harmonic vibration is described by frequency, amplitude and zero phase angle as follows

$$U(t) = A\cos(\omega t + \varphi_0) \qquad \text{Equation 2.1}$$

where

$$\omega = 2\pi f \qquad \text{Equation 2.2}$$

A... Amplitude
ω... Angular frequency
φ_0... Zero phase angle
f... Frequency.

By means of the addition theorems, we can rewrite equation 2.1 as

$$U(t) = A\cos\varphi_0\cos\omega t - A\sin\varphi_0\sin\omega t \qquad \text{Equation 2.3}$$

or

$$U(t) = A_{cos}\cos\omega t - A_{sin}\sin\omega t \qquad \text{Equation 2.4}$$

where

$A_{cos} = A\cos\varphi_0$ ... Amplitude of the cosine part
$A_{sin} = A\sin\varphi_0$ ... Amplitude of the sine part.

A harmonic vibration can thus be described as a superposition of a sinusoidal and cosinusoidal vibration whose amplitudes depend on the zero phase angle.

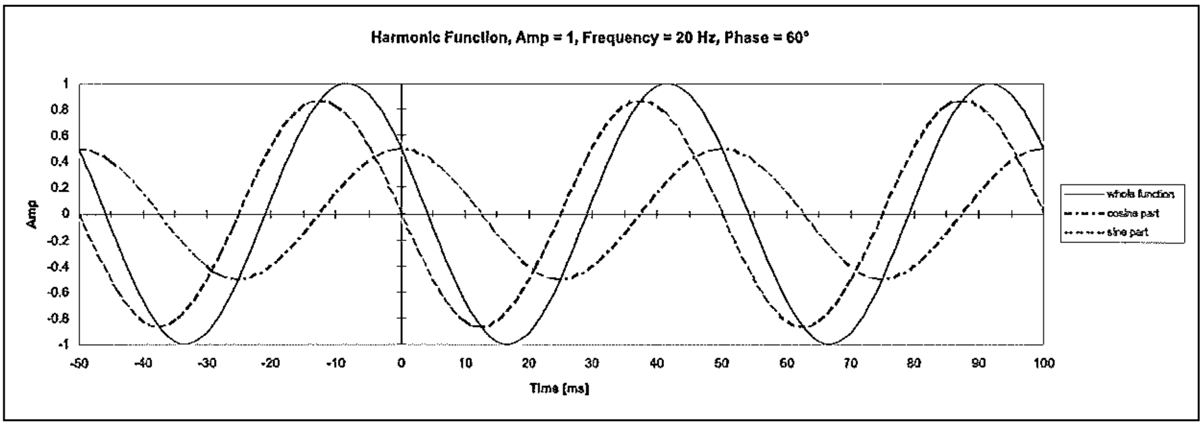


Figure 2.1: Harmonic vibration, split into cosinusoidal and sinusoidal part

2.2 Harmonic Vibrations described with Complex Numbers

Instead of trigonometric functions, you can also use complex numbers to describe harmonic vibrations. This is advantageous for mathematical analysis and allows clear presentation in the complex number plane. If you are not familiar with complex numbers, you will find a short introduction to the calculus with complex numbers in APPENDIX A.

Complex numbers are underlined in this section.

With complex numbers, a harmonic vibration U(t) can be written as

$$\underline{U}(t) = Ae^{i(\omega t + \varphi_0)}. \quad \text{Equation 2.5}$$

The argument of the exponential function comprises a time-dependent part $i\omega t$ and a constant part $i\varphi_0$.

The vibration can be made clearer in the complex pointer diagram. It corresponds to a complex pointer which revolves around the origin of coordinates with angular frequency ω.

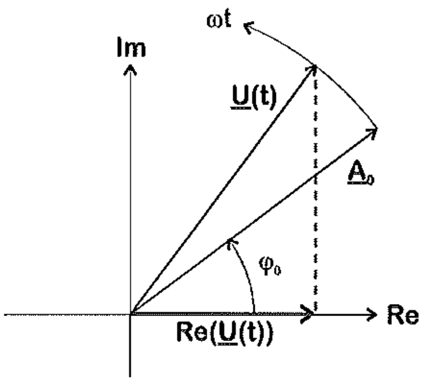


Figure 2.2: Vibration in the complex pointer diagram

The projection of the pointer to the real axis corresponds to the time-dependent instantaneous value of the real vibration.

$$\begin{aligned} \mathrm{Re}[Ae^{i(\omega t+\varphi_0)}] &= A\mathrm{Re}[\cos(\omega t+\varphi)+i\sin(\omega t+\varphi)] \\ &= A\cos(\omega t+\varphi) \end{aligned} \qquad \text{Equation 2.6}$$

Equation 2.5 can be rearranged as follows

$$\begin{aligned} \underline{U}(t) &= Ae^{i\varphi_0}e^{i\omega t} \\ &= \underline{A_0}e^{i\omega t} \end{aligned} \qquad \text{Equation 2.7}$$

where

$\underline{A_0} = Ae^{i\varphi_0}$ ... Complex amplitude.

The complex amplitude contains information on the amplitude and the zero phase angle of the vibration.

3 Transformation of the Time Signal to the Frequency Spectrum

3.1 Fourier Transformation

Periodic functions can be described as a sum of trigonometric functions (Fourier series). For example, a rectangular vibration can be described by the sum of the fundamental oscillation ($\sin\omega_0 t$=1st harmonic) and its odd harmonics. This results in

$$U_{rec}(t) = \sin\omega_0 t + \frac{1}{3}\sin 3\omega_0 t + \frac{1}{5}\sin 5\omega_0 t + \ldots$$

$$\frac{1}{7}\sin 7\omega_0 t + \ldots$$

Equation 3.1

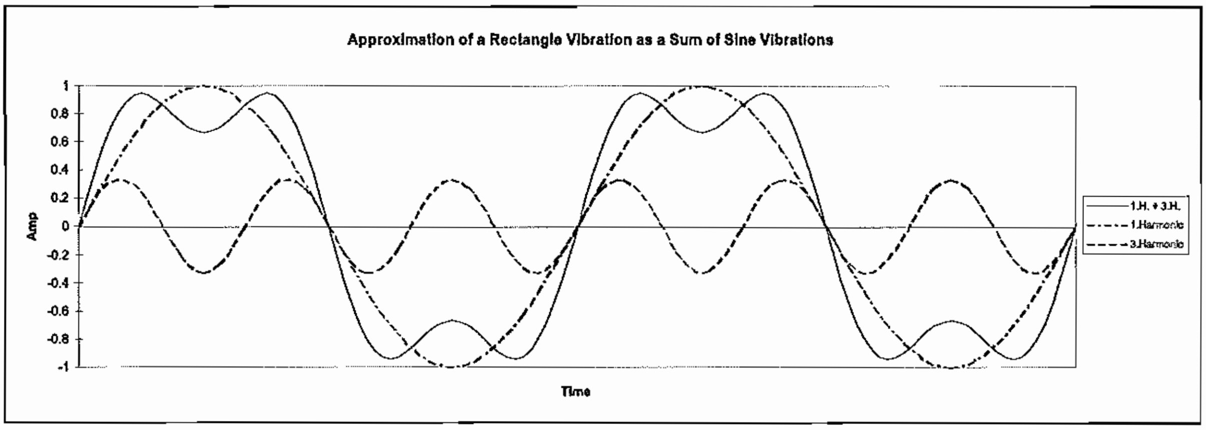


Figure 3.1: Fundamental oscillation (1st harmonic) superimposed with the 3rd harmonic

Non-periodic functions can be described as an integral of trigonometric functions (Fourier integral). An example is a single rectangular pulse.

The Fourier transformation splits any time signal into a sum of vibrations with different frequencies. All information which the time signal contains remains available. The original time signal is obtained by an inverse transformation.

3.1.1 Frequency Spectrum of a Rectangular Vibration

In the FFT spectrum of a rectangular vibration, lines appear at odd harmonics of the fundamental frequency f_0. This corresponds to splitting the rectangular vibration into sinusoidal vibrations (refer to SECTION 3.1).

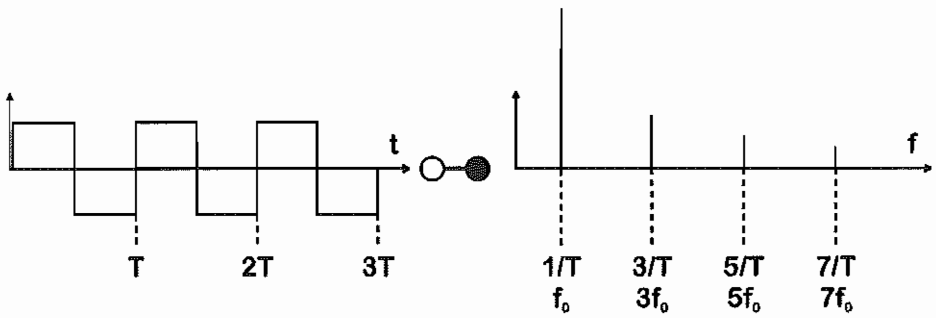


Figure 3.2: Rectangular vibration and its frequency spectrum

3.1.2 Frequency Spectrum of a Harmonic Vibration

A harmonic vibration with the frequency f_0 generates one line with frequency f in the FFT spectrum.

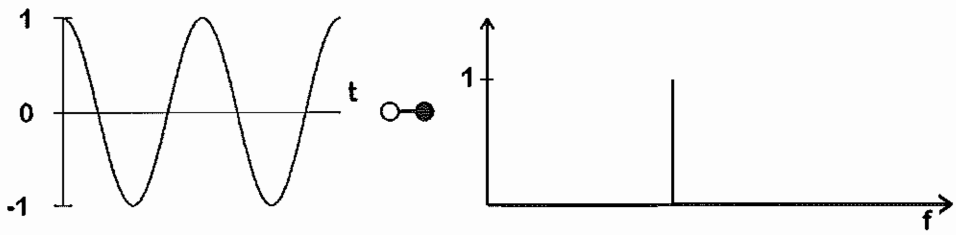


Figure 3.3: Harmonic vibration (Dirac Pulse) and its frequency spectrum

3.1.3 Frequency Spectrum of a Delta Function

The Delta Function is infinitely short and infinitely high. The integral of the Delta Function has the value 1. The frequency spectrum of the Delta Function has the value 1 at all frequencies.

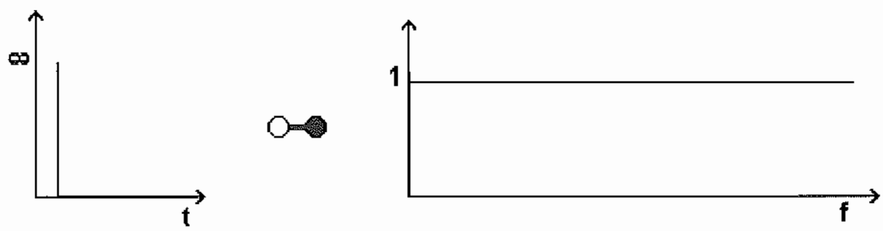


Figure 3.4: Delta Function and its frequency spectrum

An approximation of the Delta Function is a hammer blow.

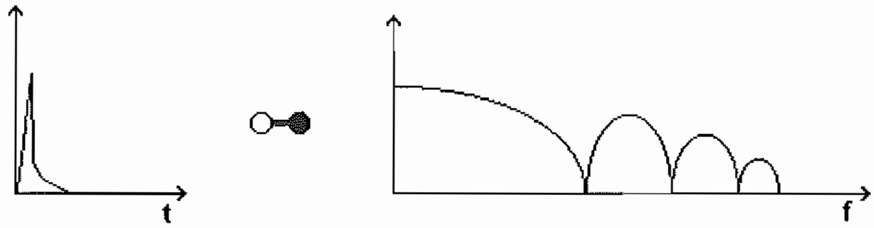


Figure 3.5: Hammer blow and its frequency spectrum

With a hammer blow a constant excitation of each frequency no longer takes place. This must be considered when using a hammer blow to excite vibrations. The FFT spectrum of a single rectangular pulse is similar to the hammer blow spectrum.

3.2 Generation of the Frequency Spectrum in the Software

The recorded time signal consists of a discrete number of samples. The software uses the FFT procedure (Fast Fourier Transformation) to generate the corresponding frequency spectrum.

Each frequency which appears in the time signal generates a spectral line in the FFT spectrum.

The number of samples which are processed by the FFT must be a power of two.

The FFT is normalized in the software such that a harmonic vibration in the time signal with amplitude 1 generates a line with amplitude 1 in the frequency spectrum if the harmonic vibration is periodic in the time window (refer to CHAPTER 5).

3.3 Calculation of 1/3 Octave Bands in the Software

1/3 octave band data is calculated from the FFT data by means of adding the square of the FFT data, dividing by two and extracting the root of this value. This is equivalent to transforming the band-limited FFT data to the time domain and calculating the RMS value of the time data. The FFT window function is taken into account with a correction factor. The display of 1/3 octave bands is also possible for signals calculated from a combination of channels (Vibrometer and Reference) like FRF, H1, H2 and Coherence. Please note that in this case first the combined signals are calculated (refer to CHAPTER 7) and then the calculation of the 1/3 octave data is done.

Center frequency

For the center frequency f_m of the nth band we have

$$f_{m,n} = 10^{0,1n} \quad \text{Equation 3.2}$$

n ... Integer.

For the output, the calculated values are rounded according to the National Standard DIN EN 60651.

Band limits

With a logarithmic frequency scale, the bands limits are symmetric with respect to the center frequency. The following applies to the lower limit $f_{l,n}$

$$f_{l,n} = \frac{f_{m,n}}{10^{0,05}} \quad \text{Equation 3.3}$$

and the upper limit $f_{u,n}$

$$f_{u,n} = f_{m,n} \cdot 10^{0,05} \quad \text{Equation 3.4}$$

As there is no standard for rounding band limits, we use our own scheme for this and thus obtain the results in TABLE 3.1.

Table 3.1: Rounding of 1/3 octave band limits

f_m [Hz]	f_l [Hz]	f_u [Hz]
1.00	0.89	1.12
1.25	1.12	1.40
1.60	1.40	1.80
2.00	1.80	2.25
2.50	2.25	2.80
3.15	2.80	3.50
4.00	3.50	4.50
5.00	4.50	5.60
6.30	5.60	7.10
8.00	7.10	8.90
10.0	8.90	11.2

Display

On condition that a band contains at least two FFT lines, 1/3 octave bands are displayed approximately from the 8th FFT line onwards.

Integration and differentiation

Integration and differentiation of 1/3 octave bands are possible and are performed by means of the center frequency. The maximum theoretical error for this amounts to ±1.0dB.

4 The Alias Effect

The software records and digitally processes analog time signals. Under certain conditions, the spectrum of digitally sampled signals may be falsified by the alias effect. In SECTION 4.1 is described how alias rejection works in the MSA, MSV and PSV. If you are not familiar with the alias effect, read SECTION 4.2.

4.1 Alias Rejection

All MSA, MSV, and PSV systems as well as the PSV 200 with an upgraded data management system provide built-in alias suppression. You do not need to take any measures to suppress aliases.

☞ If you use the high-frequency decoder VD-05 or DD-300, alias rejection is only available for bandwidths above 4 MHz or sample frequencies above 10.24 MHz. With lower bandwidths or sample frequencies high-frequency signal portions and noise levels are not suppressed and interfere the measurement signal. In this case, we recommend to use the broadband decoder.

4.2 Background Information on the Alias Effect

You can picture an actual analog time signal as a series of an infinite number of samples with an infinitely short distance. To digitally process analog time signals, they must be sampled for a certain period with a sampling frequency f_{Sample}. The number of samples becomes limited, which naturally means information is lost. It must therefore be made sure that the digital samples within the required accuracy provide the same information as the analog time signal.

If the time signal is sampled k times, the following applies

$$Wt = \frac{K}{f_{Sample}} \qquad \text{Equation 4.1}$$

Wt... Length of a measured time signal = time window
K... Number of samples
f_{Sample}... Sampling frequency.

For correct digital signal processing, the sampling theorem must be fulfilled. This is guaranteed when

$$f_{Sample} > 2f_{Signal} \qquad \text{Equation 4.2}$$

f_{Sample}... Sampling frequency
f_{Signal}... Maximum signal frequency.

Signals with frequencies $f_{Signal} > f_{Sample}/2$ generate artificial lines at frequencies $f_{Alias} < f_{Sample}/2$. This is called the **alias effect**. The spectrum is falsified. To avoid infringement of the sampling theorem, signal frequencies which are higher than half the sampling frequency must be suppressed or the sampling frequency must be high enough.

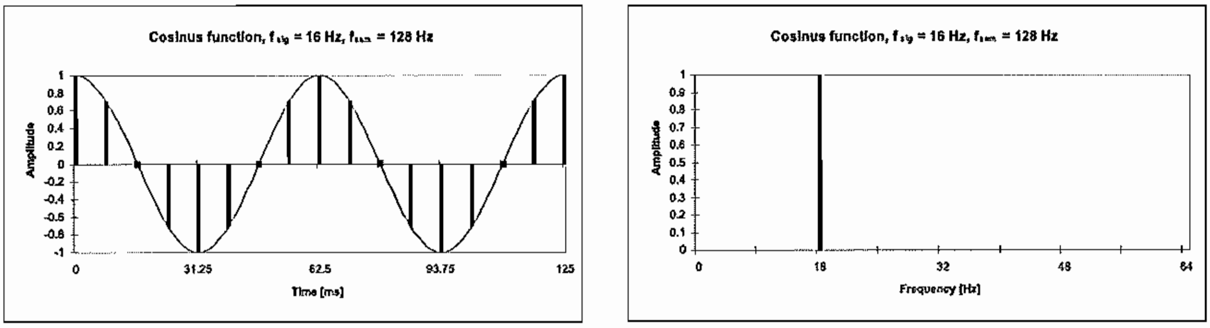


Figure 4.1: Sampling of a cosine function, sampling theorem fulfilled

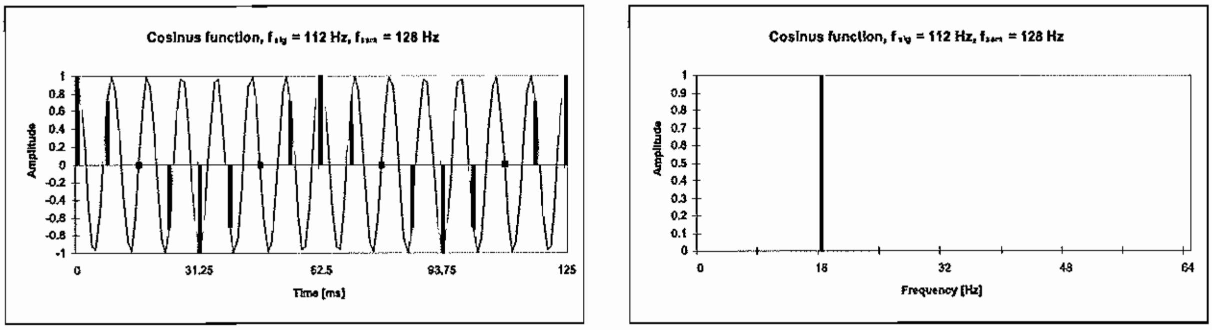


Figure 4.2: Sampling of a cosine function, sampling theorem infringed

Example Cosine function, sampled with $K=16$ and $f_{Sample}=128\,Hz$.

With $f_{Signal}=16\,Hz$, a spectral line is generated at 16 Hz. With $f_{Signal}=112\,Hz$, the spectral line is also generated at 16 Hz. The spectra of $f_{Signal}=16\,Hz$ and $f_{Signal}=112\,Hz$ cannot be distinguished. The artificial spectral line (alias) with $f_{Signal}=112\,Hz$ developed because the Nyquist theorem was infringed.

5 Window Functions

5.1 Basics

The result of the FFT is a discrete spectrum. Only frequencies which fall exactly on an FFT line are shown correctly in the frequency range. If there are frequencies in the time signal which do not fall on an FFT line, the information in the spectrum is distributed over the neighboring FFT lines. This is known as the leakage effect.

The leakage effect can be reduced by applying window functions. The time signal is weighted with the window function before calculating the FFT. For most window functions, the weighted time signal becomes zero at the start and at the end of the time window which thus avoids signal jumps at the edges of the time window.

The most simple window function is the rectangular window. The multiplication of a time signal with the rectangular window is synonymous with cutting off of the time signal outside the time window.

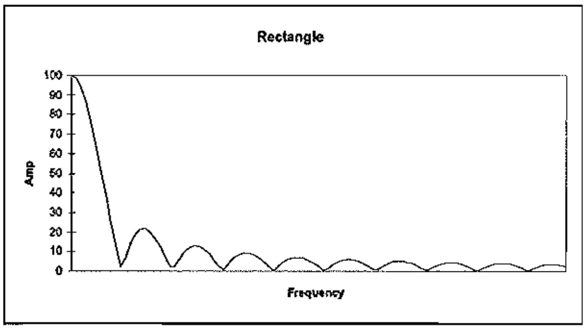
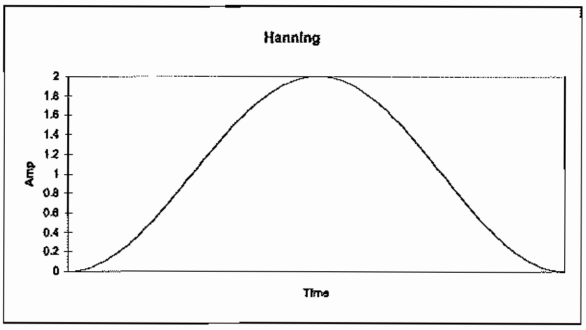


Figure 5.1: Rectangular window and its spectrum

The following applies to a periodic time signal:

- If the time signal is **periodic in the time window**, the periodic continuation of the windowed signal corresponds to the actual time signal (see FIGURE 5.3, rectangle, signal without leakage).
- If the time signal is **non-periodic in the time window**, the periodic continuation of the windowed signal no longer complies with the actual time signal. This cannot be interpreted properly by the FFT and the frequency spectrum is falsified (see FIGURE 5.3, rectangle, signal with leakage).

Generally, in actual signals the periodic continuation of the windowed signal is not the same as the actual time signal. To minimize leakage, most window functions artificially minimize the amplitudes at the beginning and the end of the time window. Thus the phase shifts are minimized in the periodic continuation of the windowed time signal. Hanning, Hamming, Blackman Harris, Bartlett and Flat Top are among these window functions.



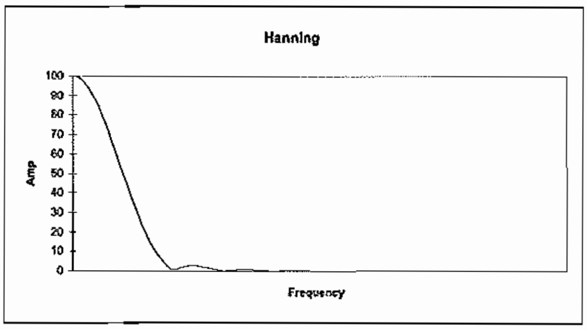


Figure 5.2: Hanning window and its spectrum

5.2 Attenuation and Ripple

All windows influence time signals which are non-periodic in the time window. A window function changes line shape and amplitude of the spectral lines in the frequency spectrum in actual measurements. Based on the spectrum of a window function, you can estimate how the window function influences the measured spectrum.

The spectrum of the rectangular window consists of a main maximum and secondary maxima. This applies to all window functions which artificially minimize amplitudes at the beginning and the end of the time window (Hanning, Hamming, Blackman Harris, Bartlett, Flat Top).

Attenuation

A measure of the frequency resolution of a window function is the frequency value by which a sharp spectral line in the windowed spectrum widens. A deciding factor is at which attenuation of the spectral line the line widening may appear.

If **low** attenuation is required, the frequency resolution depends on the width of the main maximum of the window spectrum. Half the width of the main maximum of the rectangular window (= $2\pi(f_{Sample}/K)$) serves as a means of comparison for the various window functions. The required attenuation is already achieved within the main maximum of the window spectrum and must be lower than the attenuation of the amplitude of the highest secondary maximum.

If **higher** attenuation is required, the frequency resolution depends on the amplitude of the highest secondary maximum in the window spectrum (highest side lobe attenuation). The required attenuation is achieved at the highest secondary maximum.

If **very high** attenuation is required, the frequency resolution depends on how fast the amplitudes of the secondary maxima decrease in the window spectrum (roll-off rate). The required attenuation is not yet achieved at the highest secondary maximum.

Normally, higher attenuation is required to clearly define spectral lines. The frequency resolution of a window function increases with the length of the time window.

With increasing length of the time window,

- the width of the main maximum decreases in the window spectrum,
- the amplitude of the secondary maxima in the window spectrum falls to lower values in most window functions as the window spectrum is longer.

The following applies

$$Wt = \frac{K}{f_{sam}} > \frac{n_K}{\Delta f_0} \qquad \text{Equation 5.1}$$

Wt... Time window = length of the measured time signal
K... Number of samplings
f_{Sample}... Sampling frequency
n_K... Index of the secondary maxima with required attenuation with regard to the main maximum
Δf_0... Maximum permissible one-sided widening of a spectral line.

All window functions are conceived for certain measurement tasks. With a window function which reaches a certain attenuation with a smaller n_K, you receive a higher frequency resolution with the same window width. Select a window function according to your measurement conditions.

Ripple Ripple describes the quality of the reproduction of the amplitude of a window function. A windowed sinusoidal time signal with a frequency in the center of the bandwidth is observed. Ripple is the maximum attenuation of the frequency amplitude of this signal which is non-periodic in the time window. Windows with a very wide main maximum have the least Ripple. The frequency resolution decreases with increasing width of the main maximum.

5.3 Comparison of the Rectangular Window and the Hanning Window

The rectangular window does **not** falsify the spectrum of signals which are periodic in the time window, see FIGURE 5.3.

The rectangular window **strongly** falsifies the spectrum of signals which are non-periodic in the time window.

The Hanning window falsifies the spectrum of signals which are

- periodic in the time window **more** than the rectangular window,
- non-periodic in the time window **less** than the rectangular window.

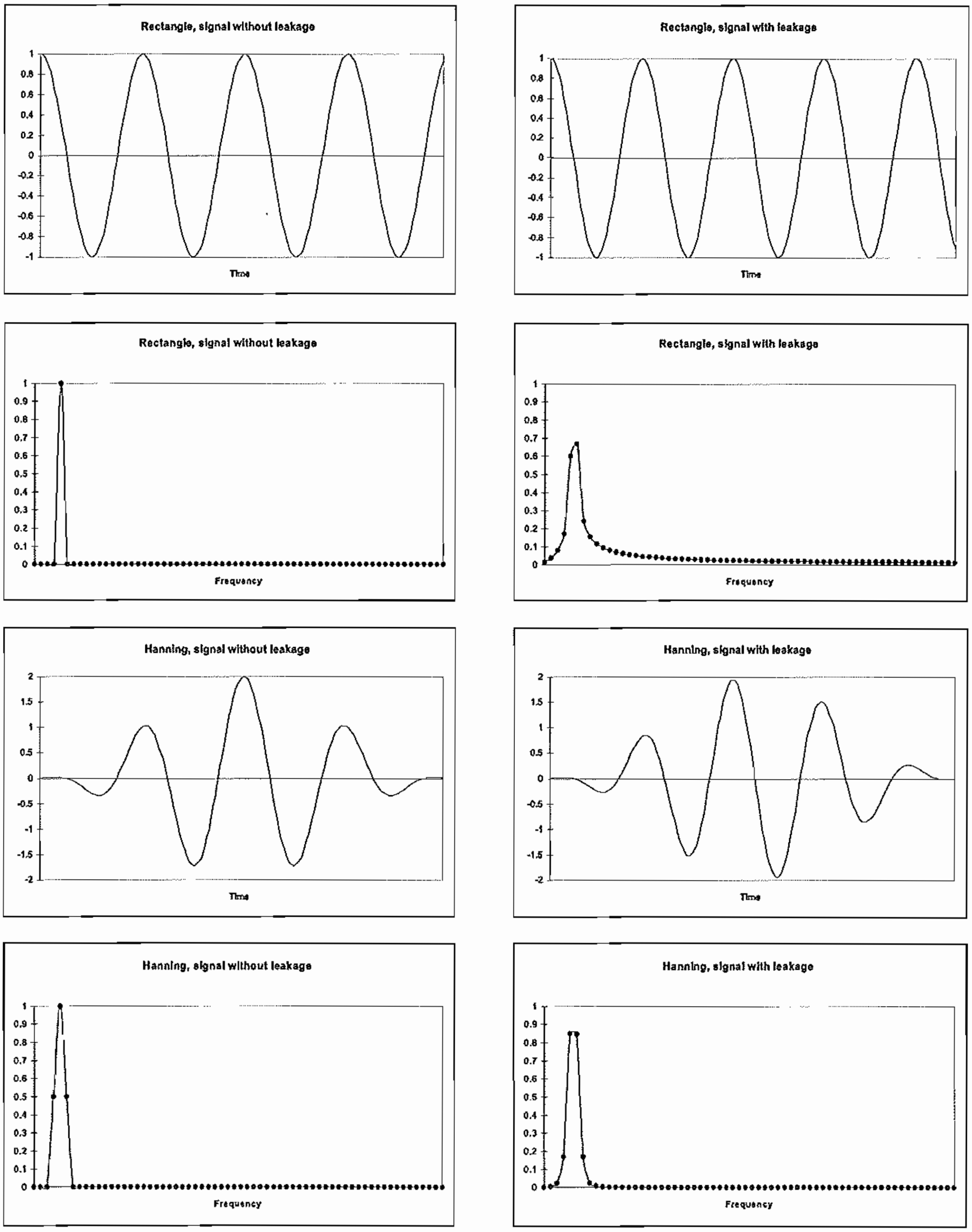


Figure 5.3: Comparison of the rectangular window with the Hanning window

5.4 Window Functions in the Software

The window functions which are implemented in the software are normalized as follows: A sinusoidal time signal which is periodic in the time window and with a frequency in the center of the bandwidth is considered. The rectangle window function reproduces the frequency amplitude of this signal in a pure manner. In order to also apply this to the window functions Hanning, Hamming, Blackman Harris, Bartlett and Flat Top, these window functions are multiplied with a scaling factor.

The individual window functions are described in detail in the following. In SECTION 12.8 you will find a brief overview of the most important parameters for the window functions implemented.

Rectangle

The main maximum in the spectrum of the rectangular window is the narrowest in comparison with other window spectrums.

Ripple:3.92dB, Highest side lobe attenuation:13.3dB.

The rectangular window is **highly** suitable

- for signals which are periodic in the window,
- for non-periodic signals which decrease to zero within the time window (e.g. hammer blows).

The rectangular window is **not** suitable

- for higher and very high frequency resolutions, as the amplitude attenuation of the highest secondary maxima is low in the spectrum (highest side lobe attenuation is low) and the amplitudes of the secondary maxima only decrease slowly (roll-off rate is low).

Hanning

The Hanning window has the shape of an inverse, lifted cosine function.

With noisy measurement signals occurring in a noise excitation, a window function should display even-sized attenuating behavior in the complete window spectrum.

Ripple: 1.42dB, Highest side lobe attenuation: 31.5dB.

The Hanning window is **highly** suitable for strong noisy measurement signals as

- the amplitudes of the secondary maxima decrease rapidly (roll-off rate is high),
- the main maximum is only double the width compared to that in the rectangular window spectrum,
- the attenuation is constant.

Hamming

The Hamming window is a combination of the Hanning window and the rectangular window.

Ripple:1.75dB, Highest side lobe attenuation: 42.6dB.

In comparison to the Hanning window, the Hamming window is **more** suitable

- for the frequency resolution of spectral lines in attenuations above the highest side lobe attenuation.

The Hamming window is **not** better suited than the Hanning window

- for very noisy measurement signals and the frequency resolution of spectral lines in an attenuation beneath the highest side lobe attenuation of the Hamming window, as the amplitudes of the secondary maxima only decrease slowly (roll-off rate is low) and the main maximum is double the width as compared to the rectangular window spectrum.

Blackman Harris

It is a good compromise for a window with hardly any influence on the line shape and amplitude of the spectral lines.

Ripple: 0.83dB, Highest side lobe attenuation: 92.1dB.

The Blackman Harris window is **highly** suitable

- for the frequency resolution of strongly attenuated spectral lines, as the highest side lobe attenuation is very large and the secondary maxima decrease quickly at the beginning,
- for periodic measurement signals.

As the main maximum in the Blackman Harris window spectrum is four times as wide as in the rectangular window spectrum, the Blackman Harris window is **not** better suited

- than the Hanning window for very noisy measurement signals as the attenuating behavior is very irregular in the Blackman Harris window spectrum,
- for the frequency resolution of weakly attenuated spectral lines.

Bartlett

The Bartlett window has the shape of a isosceles triangle.

The features of the Bartlett window lie between the rectangular window and the cosinusoidal windows Hanning, Hamming and Blackman Harris.

Ripple: 1.82dB, Highest side lobe attenuation: 26.5dB.

Flat Top

The Flat Top window is based on the cosine function. The main maximum in the Flat Top window spectrum is five times wider than in the rectangular window spectrum.

Ripple: 0.02 dB, Highest side lobe attenuation: 68.3 dB.

The Flat Top window is **highly** suitable for

- a good reproduction of the amplitude height, e.g. for calibration purposes, as the ripple is very small,
- for measurements with sinusoidal excitation.

The Flat Top window is **not** suitable

- for very noisy measurement signals, as the attenuation is very irregular,
- for measurements which require a detection of immediate spectral lines and a good reproduction of the line shapes of spectral lines.

Exponential

Unlike the other window functions, the exponential window does not attenuate signals at the beginning of the window.

The exponential window increases the attenuation proportionally. An exponentially decreasing signal is attenuated to the e-th part (e=2.718...) of its initial value according to the time constant τ.

The exponential window is **highly** suitable

- for measurement signals which are excited with pulses (hammer blow) and are only attenuated weakly. With such measurement signals, the amplitude is high at the beginning of the time window and decreases slowly in an exponential manner. If the amplitude is not nearly zero at the end of the time window, the measurement is falsified. This effect is prevented by the exponential window and it receives the characteristic exponential decrease of the measurement signal.

The exponential window is **not** suitable

- for unattenuated periodic measurement signals.

6 Averaging

Measured signals are always superimposed by noise. To minimize the noise level, you can average in the software. This chapter describes averaging in time and frequency domain.

6.1 Time Domain Averaging

In time domain averaging a sequence of time traces is collected and averaged. A time trace is a contiguous sequence of samples. As time traces are acquired at different times and combined to the average result, the measurement conditions should be repeatable and the same for each time trace. This can be achieved for example by synchronizing the measurement to the excitation with the help of a trigger.

To use time domain averaging switch the acquisition mode to Time on the General page of the A/D Settings dialog, choose averaging mode Time and select the number of averages that contribute to the average result.

The time traces are collected one after the other and have the same number of samples. A single sample of the average result at time $t = t_0 + \Delta t$ after the first sample of the result is calculated from the samples at times $t_i = t_{0i} + \Delta t$ of the time traces i. Here t_{0i} is the start of time trace i. Therefore the average result has the same number of samples as the time traces. See FIGURE 6.1 for an illustration. The illustration shows that it is necessary to trigger the data taking of every time trace synchronized to the shown sine wave. Otherwise you would not get meaningful results from time domain averaging.

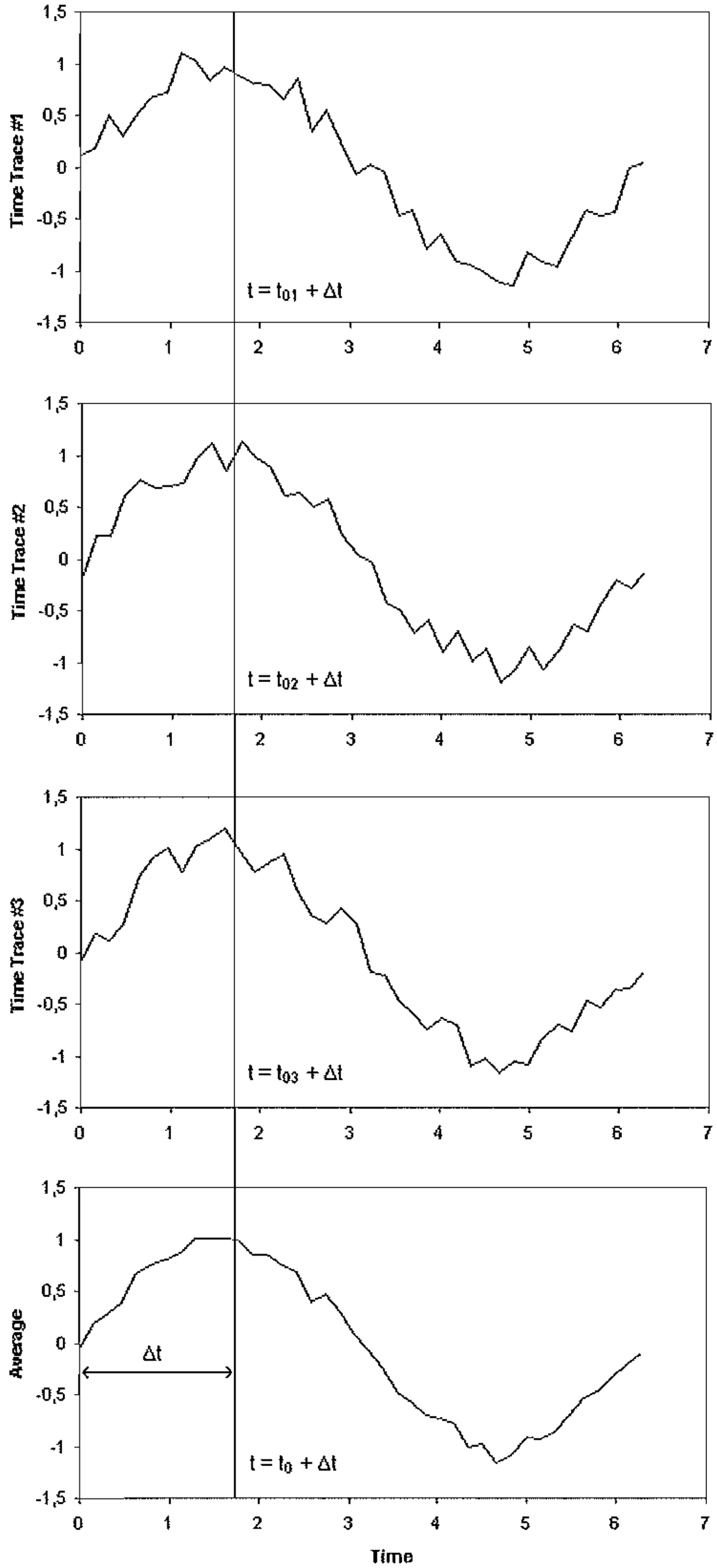


Figure 6.1: Principle of time averaging

There are two different modes available in time domain averaging: mean and median averaging. To select median averaging for an acquisition channel, check the corresponding box on the SE (Signal Enhancement) page of the A/ D Settings dialog.

In mean averaging mode the average is calculated by adding up the samples and dividing by the number of samples:

$$\bar{T} = \frac{1}{N} \cdot \sum_{n=1}^{N} T_n \qquad \text{Equation 6.1}$$

In median averaging mode the samples at a given time after start of the traces are first sorted and then the middle value of the sorted values is used as the average value. If the number of traces is even, the mean of the two values adjacent to the middle is calculated. Median averaging mode is especially useful to suppress low probability, high amplitude noise, such as dropouts of the vibrometer signal.

The following table demonstrates the differences between median and mean averaging mode. Column A shows an example for 3 measurement values to be averaged. Both, the mean and median average give the same result. Column B shows the same sequence, except the middle value, which has been altered by a dropout in the vibrometer signal. The dropout clearly distorts the mean average, whereas it has little effect on the median average.

Trace/Sample	#1	#2
#1	3	3
#2	2	20
#3	4	4
Mean average	3	9
Median average	3	4

6.2 Frequency Domain Averaging

As in time domain averaging, in frequency domain averaging a sequence of time traces is collected. Each time trace has the same number of samples. From each time trace a spectrum is calculated by the means of an FFT. All spectra have the same number of FFT lines. The averaged spectrum is obtained by averaging all values at each frequency.

The following sections describe the different modes available in frequency domain averaging. There are some general rules for selecting complex or magnitude averaging mode for different applications:

If the phase between output and input signal is stable you can use complex averaging to reduce noise that is not phase correlated to the input signal. If the phase between output and input signal is not stable you can use magnitude averaging to obtain an average amplitude.

For example, complex averaging is used for deterministic excitations like a shaker driven with a periodic chirp signal whereas magnitude averaging is used for stochastic excitations like in a wind tunnel.

6.3 Complex Averaging

With complex averaging, N real parts and N imaginary parts of N measurement values are added and divided by N.

$$\bar{S} = \frac{1}{N}\sum_{n=1}^{N} S_n = \frac{1}{N}\cdot\left(\sum_{n=1}^{N} \mathrm{Re}(S_n) + i\cdot\sum_{n=1}^{N} \mathrm{Im}(S_n)\right) \qquad \text{Equation 6.2}$$

This corresponds to the pointer in FIGURE 6.2: $\frac{1}{2}\cdot(S_1 + S_2)$.

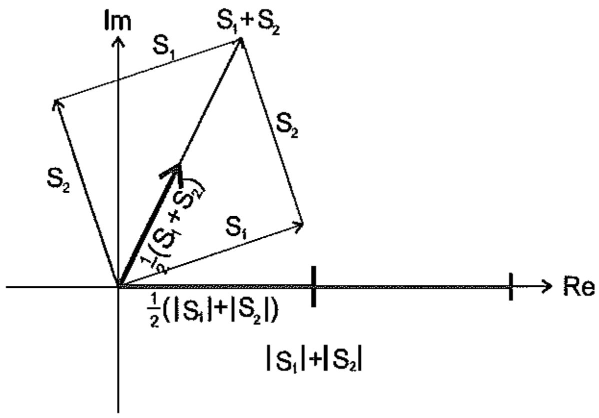


Figure 6.2: Complex and magnitude averaging of signals S_1 and S_2 (number of averages 2)

☞ If you perform measurements without a trigger the start of the measurement and therefore the phase is arbitrary. Nevertheless there is a fixed relation between the phase of the reference channel and the vibrometer channel. Prior to complex averaging the software relates the phase of all channels to that of the reference channel with the lowest number (see TABLE 12.2).

6.4 Magnitude Averaging

With magnitude averaging, first the magnitudes of the complex values are calculated, then these N magnitude values are added and divided by N.

$$\overline{|S|} = \frac{1}{N} \cdot \sum_{1=n}^{N} |S_n| \qquad \text{Equation 6.3}$$

This corresponds to the length of $\frac{1}{2}(|S_1| + |S_2|)$ in FIGURE 6.2.

☞ For crosspower signals complex averaging is used even if magnitude averaging mode is selected on the A/D Settings general page, refer to CHAPTER 7.

When using magnitude averaging, usually all phase information is lost. To avoid this, the software assigns the phase of the crosspower signal with the reference channel with the lowest number to the averaged result of the other channels (see TABLE 12.2). This phase only makes sense if there is some phase correlation between reference and vibrometer channel.

6.5 Peak Hold Averaging

Select Peak Hold for averaging if you want to calculate and display the respective maximum of the spectra over the set number of spectra.

The reference channel plays a special role with Peak Hold, as the measurement values of this channel decide which measurement values are to be used in the Peak Hold average spectrum for all channels. If several reference channels have been selected, then the one with the lowest channel number is used. If no reference channel has been selected, then the vibrometer channel with the lowest channel number is used. In the following, only the term reference channel is used.

During the measurement the spectra of the reference channel are analyzed. If, at a certain frequency, the magnitude of the current spectrum exceeds the maximum magnitude saved until now, then the measurement values of **all channels** at this frequency are saved as Peak Hold values. If there are complex measurement values, then they are also saved as complex values; however only the magnitude of the reference channel is used as the comparative criteria.

The way this algorithm works can be shown using as an example a Sweep excitation, which is connected to the reference channel. At the current Sweep frequency, the spectrum of the reference channel shows a peak. The magnitude of this peak is usually larger than that of all previous spectra. For this reason, the measurement values of all channels at this Peak frequency are copied into the Peak Hold average spectra. Once the Sweep has finished, the Peak Hold spectra from all channels are made up of data which corresponds to a peak magnitude of the reference.

This approach has several advantages. The Peak Hold spectra contain the required data, i.e. the data at which excitation was at a maximum. Apart from that, it is ensured that the measurement values from all channels at a given frequency come from spectra acquired at the same time. Therefore the H1, H2 and coherence signals can be calculated in the usual consistent way (refer to CHAPTER 7). Furthermore, a brief drop out of the vibrometer signal in a single spectrum only affects the frequencies around the current Sweep frequency, but not the whole frequency range.

To further improve the signal quality, you can activate Signal Enhancement for the relevant channels. Then the combined signal quality of these channels is analyzed. The quality of the averaging spectra is compared to a threshold and as a result of this, the measurement values are either discarded for all channels or are used for calculating the Peak Hold spectra. In a sequence of measurements, the threshold automatically adapts to the average quality of the signals.

☞ If you select Peak Hold averaging, you cannot make any further quality adjustment for Signal Enhancement (Fast ... Best).

☞ If you want to use a Sweep excitation together with Peak Hold averaging, the sweep time should correspond to the measurement time. As a rule of thumb, the number of averages should equal to the number of measured FFT lines. To calculate the measurement time, multiply the number of averages with the sample time (displayed on the A/D settings dialog's frequency page) and 100% minus the used overlap (in percent). The measurement time should be slightly larger than the sweep time to ensure that all frequencies of the sweep contribute to the result.

☞ Disable all reference channels if you want to perform the Peak Hold based on the signal of the vibrometer channel.

7 Calculation of Frequency Response and Coherence

The frequency response of a vibrating system is the magnitude and phase response of the system at all frequencies of interest. The frequency response is defined as the Fourier Transform of the Impulse Response of a system.

Frequency response measurements require the excitation of the vibrating system with energy at all measured frequencies. The fastest way to perform the measurement is to use a broadband excitation signal that excites all frequencies simultaneously, and use FFT techniques to measure at all of these frequencies at the same time.

The coherence function is a measure of the power in the output signal caused by the input. If the coherence is 1, then all the output power is caused by the input. If the coherence is 0, then none of the output is caused by the input.

In PSV and VibSoft the frequency response (FRF, H1, H2) and coherence functions (COH) are calculated in several steps. First FFTs are calculated of all active channels. Then for each channel the auto power spectra (AP) and for every possible combination of a Vibrometer and reference channel the cross power spectra (CP) are calculated:[1]

$$AP_{SS} = S^* \cdot S \qquad \text{Equation 7.1}$$

$$CP_{RV} = R^* \cdot V \qquad \text{Equation 7.2}$$

$$CP_{VR} = V^* \cdot R = CP_{RV}^* \qquad \text{Equation 7.3}$$

Here S is the spectrum at any channel, V the spectrum of a Vibrometer channel (output) and R the spectrum of a reference channel (input). * denotes the complex conjugate (refer to SECTION A.4).

Without averaging the FRF is calculated from the cross power and auto power spectra:

$$FRF_{VR} = \frac{CP_{RV}}{AP_{RR}} = \frac{V}{R} \qquad \text{Equation 7.4}$$

[1] All variables in this chapter (AP, CP, S, V, R, FRF, H1, H2, N) are functions of the frequency f. For better readability the argument (f) is omitted in the functions.

With averaging the response functions H1 and H2 and the coherence function COH are calculated:

$$H1_{VR} = \frac{\overline{CP_{RV}}}{\overline{AP_{RR}}} \qquad \text{Equation 7.5}$$

$$H2_{VR} = \frac{\overline{AP_{VV}}}{\overline{CP_{VR}}} \qquad \text{Equation 7.6}$$

$$COH_{VR} = \frac{H1_{VR}}{H2_{VR}} = \frac{\overline{CP_{RV}} \cdot \overline{CP_{VR}}}{\overline{AP_{VV}} \cdot \overline{AP_{RR}}} \qquad \text{Equation 7.7}$$

Here the overlined values denote averaged values. As the CP signals are always averaged in complex averaging mode and AP signals are real, H1, H2 and COH do not depend on the averaging mode.

H1 and H2 are estimators for the frequency response function FRF_{sys} of the measured system. While the phase is equal for H1 and H2, the magnitude differs. H1 is mainly affected by noise in the input signal (reference signal), whereas H2 is mainly affected by noise in the output signal (vibrometer signal).

☞ Without averaging H1 and H2 have the same result as FRF_{VR} in equation 7.4. The coherence has always the value 1. Therefore without averaging FRF is displayed instead of H1 and H2. The coherence is not displayed.

The following approximations can be made (the higher the number of averages, the better the approximation):

if $N^2{}_R \ll AP_{RR}$:

$$H1 = FRF_{sys}\left(1 - \frac{N^2{}_R}{\overline{AP_{RR}}}\right) \qquad \text{Equation 7.8}$$

if $N^2{}_V \ll AP_{VV}$

$$H2 = FRF_{sys}\left(1 + \frac{N^2{}_V}{\overline{AP_{VV}}}\right) \qquad \text{Equation 7.9}$$

Here, $N^2{}_R$ is the power of the noise in the input signal and $N^2{}_V$ is the power of the noise in the output signal.

It can be seen that with the presence of input noise H1 is smaller than FRF_{sys} and with the presence of output noise H2 is bigger than FRF_{sys}.

As the coherence function is H1/H2, it can be approximated as:

$$COH = \frac{1 - \frac{N^2_R}{\overline{AP}_{RR}}}{1 + \frac{N^2_V}{\overline{AP}_{VV}}} \qquad \text{Equation 7.10}$$

A further approximation for $N^2_R \ll \overline{AP}_{RR}$ and $N^2_V \ll \overline{AP}_{VV}$ results in:

$$COH = 1 - \left(\frac{N^2_R}{\overline{AP}_{RR}} + \frac{N^2_V}{\overline{AP}_{VV}}\right) \qquad \text{Equation 7.11}$$

Example 1

A coherence value of 0.99 indicates that the sum of the relative input noise power and the relative output noise power $\left(\frac{N^2_R}{\overline{AP}_{RR}} + \frac{N^2_V}{\overline{AP}_{VV}}\right)$ is approximately 0.01. Coherence values close to 1 indicate a good signal-to-noise ratio.

Example 2

A coherence value of 0.1 indicates that the relative input noise power or the relative output noise power or both of them are high. The approximation formula is not valid anymore as $N^2 \ll AP$ is not fulfilled. Coherence values close to zero indicate a bad signal-to-noise ratio.

☞ If the number of averages is increased:

- H1 converges to a smaller value than FRF_{sys}, depending on the input noise.
- H2 converges to a bigger value than FRF_{sys}, depending on the output noise.
- COH converges to a smaller value than 1, depending on the input and output noise.

☞ For scanning measurements, normally the output (vibrometer) noise is bigger than the input (reference) noise, at least at some scan points. For visualizing an operating deflection shape (where all scan points are displayed simultaneously), H1 is the better choice than H2 because H1 is less sensitive to output noise.

8 Excitation Signals

The quality of a vibration measurement depends strongly on the choice of the excitation signal. The principal criterion for the selection of the excitation signal is the purpose of the measurement. In case of data acquisition for modal analysis typically a complete spectrum must be measured at each scan point. Not all measurement tasks require a modal analysis. Questions like "where on the structure is the highest vibration amplitude?" can be answered much faster by measuring the deflection shapes at the dominant resonance frequencies.

The linearity of the system also plays an important role for the selection of the excitation signal. If the device under test has non-linearities it is often desirable to get a linear approximation. This is particularly important for doing a modal analysis, as the used parameter estimation schemes are based on linear system models. Only certain excitation signals have the ability to average out non-linearities. With other signals non-linear distortions are clearly visible in the spectrum.

An important difference between excitation signals is the RMS-to-peak ratio, which is closely coupled to the obtained signal-to-noise ratio of the measurement. A higher RMS-to-peak ratio denotes a signal with higher energy content for a given peak amplitude. Generally, the higher the excitation energy, the lower the relative noise, at least insofar as the system behaves linearly.

Some excitation signals generate leakage effects in the spectrum calculated by FFT, which are an additional noise source (refer to CHAPTER 5). However, a variety of signals exists which do not generate leakage effects intrinsically.

A further criterion is the reproducibility of the measurement. A scanning vibrometer measures all points sequentially. If the excitation is the same for all scan points and the test object and the test setup remain unchanged during the measurement, the sequential measurement is equivalent to a parallel one. If the excitation signal is exactly the same for each scan point, the vibrometer signal can be displayed as area data. If the excitation signal is different from scan point to scan point, the frequency response function must be used to visualize area data.

Available excitation signals

The signals available in the PSV software can be grouped into four classes: harmonic, periodic in the time window, random and transient. Some signals belong to more than one class (see TABLE 8.1).

Table 8.1: Available excitation signals and their classes

Signal	Class	RMS-to-peak	Leakage	Recommended window	Suitable for MIMO
Sine	Harmonic	0.7	no[1]	Rectangle[1]	No
Sweep	(Pseudo) Harmonic	0.7	yes	Hanning	No
Pseudo Random	Periodic	0.25	no	Rectangle	No
Periodic Chirp	Periodic	0.5	no	Rectangle	No
Burst Chirp	Transient	0.35	no[2]	Rectangle	No
White Noise	Random	0.25	yes	Hanning	Yes
Burst Random	Transient, Random	0.2	no[2]	Rectangle	Yes

[1] If frequency corresponds to an FFT-line

[2] If response dies out within the time window

- **Harmonic** signals have the best signal-to-noise ratio and allow fast measurements at single frequencies.
- Signals which are **periodic** in the time window are best suited for fast measurements of complete spectra as they excite all frequencies simultaneously and do not generate leakage effects.
- If a linear approximation of a non-linear system is required, random signals must be used. Only with **random** signals non-linear distortions are averaged out.
- **Transient** signals excite a short vibration which dies out.The time window should be selected long enough to record the complete vibration signal until it died out. No leakage occurs.

☞ External generators do not offer all of the described signals nor does the internal generator of PSV-300-U or PSV-400-B systems.

Sine: Sine excitation is used to measure the deflection shape at one particular frequency. The main advantages of Sine excitation are the very good signal-to-noise ratio and the possibility to perform a scan in a very short time. For scanning with sine excitation only the values at the excitation frequency need to be measured and saved. This can be done most efficiently using the least square method regression (FastScan), which is faster than an FFT and never suffers from leakage effects.

☞ Non-linearities can be detected by looking for harmonics in the spectrum. For that purpose measure in the FFT mode.

Sweep: Sweep denotes a sine signal, whose frequency is slowly altered, according to a ramp function. Slowly swept sine can be used for single point measurements, in combination with the Peak Hold function.

With Sweep excitation the resonance of a very lightly damped structure can be found which might remain undetected with other excitation signals.

The measurement time is proportional to the square of the frequency resolution. This means that normally the measurement is very slow and therefore is hardly ever used for scanning.

Periodic Chirp: Periodic Chirp is designed to excite all FFT lines of the measured spectrum. The time signal is generated out of the spectrum by an inverse Fourier transformation. Typically the magnitude is set for all frequencies to the same value. The phase is generated by an algorithm which maximizes the energy for a given maximum amplitude.

After waiting for steady state conditions the excitation and the response are measured without leakage effects. As all frequencies of interest are excited simultaneously no averaging is required. This is very useful in order to do fast measurements. However, for precise measurements averaging can be used in order to increase the signal-to-noise ratio.

The use of the rectangle window is required. Any other window will lead to major distortions.

Pseudo Random: Like Periodic Chirp, Pseudo Random is generated in the frequency domain. The only difference is the phase which is calculated as a uniformly distributed random number, giving the signal its random sound. The time signal is generated out of the spectrum by an inverse Fourier transformation. The properties of Pseudo Random are the same as for Periodic Chirp, the main difference is that the RMS-to-peak ratio is smaller for Pseudo Random.

☞ Although Pseudo Random has the word "random" in its name, it is no random signal. Once generated using random numbers for phase, it is repeated over and over again.

☞ If a MIMO measurement (refer to CHAPTER 9) has to be performed, Pseudo Random is not suitable as excitation signal. Although a different random number sequence is generated for every channel, the principal component analysis cannot be performed, as those signals are repeated over and over again. Use Burst Random or White Noise excitation for MIMO measurements.

For linear systems the FRFs are the same for Periodic Chirp and Pseudo Random excitation. If measuring non-linear systems, Periodic Chirp and Pseudo Random both generate response signals with different distortions. Therefore, comparing the results with both excitation signals is a good method to check for non-linearity.

Burst Chirp: Burst Chirp is a fast swept sine signal followed by a zero signal. The data acquisition must be synchronized to the excitation by connecting the SYNC output of the generator to the external trigger input. In order to avoid leakage, the sample time (displayed on the frequency page) has to be chosen such that the response signal has decayed to zero at the end of the time window. Moreover the rectangle window has to be used.

To allow for time to reactivate the trigger, the complete chirp signal (including pause) is 20% longer than the selected time window.

For Burst Chirp the start and the end frequency is specified. To reverse the signal the start frequency can be set higher than the end frequency. The start (delay to SYNC) and duration of the chirp is specified in % of the sample time (displayed on the frequency page). Burst Chirp is generated in the time domain.

Burst Random: Burst Random is a random signal followed by a zero signal. Each individual burst is a different random signal, which excites non-linearities differently for each single measurement. When using a sufficient number of averages (~25), a good linear approximation of the system can be obtained. Burst Random excitation is suitable for MIMO measurements (refer to CHAPTER 9).

The data acquisition must be synchronized to the excitation by connecting the SYNC output of the generator to the external trigger input. In order to avoid leakage, the sample time (displayed on the frequency page) has to be chosen such, that the response signal has decayed to zero at the end of the time window. Moreover the rectangle window has to be used.

To allow for time to reactivate the trigger, the complete burst signal (including pause) is 20% longer than the selected time window.

The start (delay to SYNC) and duration of the burst is specified in % of the sample time (displayed on the frequency page). Burst Random is generated in the time domain.

White Noise: White Noise is a random signal with a flat spectrum adapted to the measured bandwidth. In difference to Pseudo Random, White Noise is not periodic in the time window but generated with a practically new sequence of random numbers over and over again.

White Noise is neither periodic nor does it allow the response to die out within the time window, therefore leakage occurs. In order to reduce the leakage effect, windowing - typically with the Hanning window - is applied.

As the input signal is always delayed by the measured system, only a part of the response correlates with the excitation. At the beginning of the sample period the response contains information caused by an excitation prior to the sample period. A part of the response excited in the sample period will occur only after the sample period. Both facts generate additional noise which can be reduced by a long sample time and averaging.

It is recommended to use the Hanning window and about 25 averages. The measurement can be sped up using 50% overlap, provided your system supports overlap. When using a sufficient number of averages (~25), a good linear approximation of the system can be obtained. White Noise excitation is suitable for MIMO measurements (refer to CHAPTER 9).

Square, Triangle and Ramp: Those signals are available for special applications.

User defined: User defined signals are offered to allow for signals which are not implemented in the software.

9 Multiple Reference Analysis (MIMO)

9.1 What Is MIMO?

MIMO means Multiple Input Multiple Output and is a measuring technique where multiple inputs (excitations, references) are used to excite the measurement object at the same time and multiple outputs (responses) of the vibration are measured to obtain a matrix of FRFs between all excitation and response points that describes how the vibrating system reacts to an excitation.

9.2 Why Using Multiple References?

Setting up a multiple reference measurement is not an easy task and requires a good degree of careful preparation, understanding of the measurement and cross checks of the underlying assumptions to be successful. Nevertheless multiple reference tests are an important tool for the following reasons:

- Using multiple inputs allows to put energy into the structure under test at several positions. Especially for large structures it is easier to provide enough energy with multiple inputs compared to a single input to excite global modes.
- If the structure under test exhibits closely coupled modes or repeated roots, the only way to insure that all modes can be identified is to measure with multiple references.

9.3 Example Application Using PSV

This section describes step by step the set up and analysis of a MIMO test using a scanning vibrometer. A typical application for MIMO is to find the modal shapes and mode properties of a large structure, such as a car body in white.

Using a PSV-400-H4 or PSV-300-H system, up to three shakers can be used to excite the structure at different positions. With White Noise or Burst Random, an uncorrelated broadband random excitation generated by the 3 output channels of the PSV's internal generator is used to drive the shakers. Generally we recommend to use a burst random signal combined with a rectangle window function for MIMO tests. Activate the check box Multiple Channels on the page Generator in the dialog Acquisition Settings.

Force cells are used to measure the force fed into the structure. The force cells are connected to the reference channels of the PSV system. The channel properties are set according to the calibration factors of the cells. Activate the check boxes of all reference channels in the Ref column of the page Channels in the dialog Acquisition Settings.

At this time, you might want to check if the forces measured by the cells are uncorrelated. To do this, proceed as follows:

1. On the page General in the dialog Acquisition Settings, select the desired FFT measuring mode (except FastScan), magnitude averaging (see SECTION 6.4) and the number of averages. You have to provide at least M+2 averages where M is the number of reference channels.

2. Check the box Principal Component Analysis (MIMO) to let the software calculate the MIMO FRFs, principal inputs, multiple and virtual coherences during data acquisition.

3. Switch the generator on.

4. Start a continuous measurement in acquisition mode.

5. Have a look at the coherence signals between the various reference channels. The coherence signals should be near to zero over the whole frequency range, as the internal generator provides uncorrelated random signals on its three output channels. Nevertheless, the coupling of the shakers via the structure might lead to a remaining correlation between the driving forces. You might want to optimize the positions of the shakers to minimize this effect.

6. Have a look at the principal inputs signal. To do this, select the references channel. You will see three graphs (one for every reference channel). These graphs are the eigenvalues of the auto power / cross power matrix of the reference channels for every single frequency line. For every frequency the eigenvalues are sorted by size, so that graph one always contains the largest eigenvalue and the last graph contains the smallest eigenvalue. Therefore there is no direct link to the reference channel. Nevertheless you can see, if one or more graphs will show values that are near to zero and are very small compared to the others. Please note that this might be the case for a range of frequencies only. This indicates, that some of the references are correlated. Again you might want to optimize the positions of the shakers.

Although PSV offers just a single response channel, scanning the structure with the laser provides fast and efficient means to perform a sequence of MISO (multiple input, single output) measurements with a roving output. Due to the steady state condition and because of the inputs are measured at every scan point, these MISO measurements can be combined to one MIMO data set.

Now you can set up the geometry of the scan points to cover the parts of interest of the structure to the desired resolution. If you intend to use the measured set of FRFs for modal analysis, you **should** measure the responses in the excitation points (DOFs) to obtain the driving point function. You can enter the indices of the driving points as reference point indices of the reference channels on the page Channels in the dialog Acquisition Settings. You should also set the direction of the forces and the measured vibration for every active channel on this page according to the geometry of your test set up. Furthermore, we recommend to enter the distance from the scanning head to the object at this time if you plan to export the data for further modal analysis (see below). Now start the scan.

After the scan has finished you can use the PSV presentation mode to analyze the deflection shapes at the resonances of the structure. You might want to export the FRFs and analyze them further with a modal analysis software package like Vibrant's ME'Scope to find the modal parameters and shapes of the structure.

As you have set the reference number indices, the directions of the inputs and outputs and the distance to the object before starting the measurement, no additional information has to be entered at the time of export apart from the choice which data to export.

9.4 The MIMO Model

This section describes the dynamic model that is used by PSV to obtain the FRFs, principle inputs and coherence signals during a MIMO test. The MIMO model is a linear frequency domain model where spectra (Fourier transforms) of multiple inputs are multiplied by elements of an FRF matrix to yield spectra of multiple outputs. The FRF matrix model can be written as:

$$V_N(f) = H_{NM}(f) \cdot R_M(f) \qquad \text{Equation 9.1}$$

Here M is the number of inputs (references), N the number of outputs (responses), f the frequency, $V_N(f)$ the vector of outputs, $R_M(f)$ the vector of inputs and $H_{NM}(f)$ the matrix of the FRFs describing the system. If $H_{NM}(f)$ is known, the response of the system to a set of inputs can be predicted.

$H_{NM}(f)$ is a result of the type of MIMO test described above, where N is the number of scan points and M the number of the reference channels. To obtain $H_{NM}(f)$ the software performs the following steps at every scan point:

1. A series of time traces is acquired. The number of traces corresponds to the number of averages specified. The signals at the response channel (vibrometer channel) and the reference channels are acquired simultaneously.

2. The window functions are applied to the time traces and a FFT (fast Fourier transform) is calculated for every channel and for every trace.

3. The auto power signals of all channels and the cross power signals of all combinations of response and reference channels are calculated and averaged over the spectra. For the cross power signals complex averaging is used (see CHAPTER 7).

4. The eigenvalue of the M by M matrix of the auto powers and cross powers $R_M(f) \cdot R_M(f)^*$ are calculated for very frequency f and sorted by size. These eigenvalues are stored as the principal inputs signal in the references channel.

5. The principal component analysis is performed on this set of cross power and auto power signals to obtain the FRFs of this scan point:

$$H_{iM}(f) = (V_i(f) \cdot R_M(f)^*) \cdot (R_M(f) \cdot R_M(f)^*)^{-1} \qquad \text{Equation 9.2}$$

   Here i is the index of the current scan point, $V_i(f)$ the response measured by the vibrometer at this point and $R_M(f)$ the vector of the references measured. R^* denotes the transposed complex conjugate of the vector R, $(V_i(f) \cdot R_M(f)^*)$ is the 1 by M vector of the cross powers between the responses and references and $(R_M(f) \cdot R_M(f)^*)^{-1}$ the inverted M by M matrix of the auto powers and cross powers of the references.

6. The coherence signal is calculated for the current scan point. The coherence is a measure of the input energy visible at the output of the system. The software calculates two types of coherences, the virtual coherences and the multiple coherence. The multiple coherence is available for every response channel and is common for all reference channels. Only this signal can potentially reach a value of 1. The virtual coherences between the output channel and the principal inputs do in general never reach a value of 1. The Multiple Coherence is the sum of the virtual coherences over all reference channels. You will find both signals in the corresponding response channel. The virtual coherences signal contains M graphs. The first graph is the coherence between the response channel and the first principal input, i.e. the largest eigenvalue of the auto power / cross power matrix of the reference channels. The last graph is the coherence between the response channel and the smallest eigenvalue, respectively. The virtual coherences can be used to check how the energy put into the system is spread over the object. There might be parts of the object or frequency ranges, where the effective number of references is smaller than M. In this case some of the virtual coherences are near to zero and very small compared to others. In this case you might want to optimize the positions of the points where you put the energy on to the system.

7. The coherences between the input channels are calculated. This allows for checking the correlation between the inputs. These coherences should be near to zero.

After the scan has finished, all elements of the FRF matrix $H_{NM}(f)$ are available for analysis.

To be able to solve equation 9.2, the following conditions have to be met:

1. The inputs R_M have to be uncorrelated between channels.

2. The inputs R_M have to be uncorrelated between time traces that contribute to the averages.

3. For all inputs R_M and all outputs V_N (f) the same window function has to be used.

4. The number of averages has to be at least M+2.

When you activate the Principal Component Analysis (MIMO) check box on the page General in the dialog Acquisition Settings and you are using the internal generator of the PSV-300-H or PSV-400-H4 system, the software automatically checks the above conditions.

☞ The software is not limited to a single output channel. You could use two of the acquisition channels as output and two as input by checking the corresponding check boxes in the Ref column on the page Channels in the dialog Acquisition Settings. The software then correctly calculates the matrix $H_{22}(f)$ and the two multiple coherences of the output channels. This is the case with the PSV-3D where you measure three outputs simultaneously.

To calculate the output signal, respectively three neighboring data points of the input signal are multiplied with the filter coefficients and the results are added together.

1st data point:

−4	0	4	7	9	10	9	7	4	0	−4
*	*	*								
1/4	1/2	1/4								
−1	0	1								
	+									
	0									

2nd data point:

−4	0	4	7	9	10	9	7	4	0	−4
	*	*	*							
	1/4	1/2	1/4							
	0	2	1.75							
		+								
	0	**3.75**								

3rd data point:

−4	0	4	7	9	10	9	7	4	0	−4
		*	*	*						
		1/4	1/2	1/4						
		1	3.5	2.25						
			+							
	0	3.75	**6.75**							

4th data point:

−4	0	4	7	9	10	9	7	4	0	−4
			*	*	*					
			1/4	1/2	1/4					
			1.75	4.5	2.5					
				+						
	0	3.75	6.75	**8.75**						

...

Result:

	0	3.75	6.75	8.75	9.5	8.75	6.75	3.75	0	

The low-frequency input signal is emitted nearly unchanged. The maximum deviation to the input signal is 5%.

High frequency signal

−8	0	8	−8	0	8	−8	0	8	−8	0

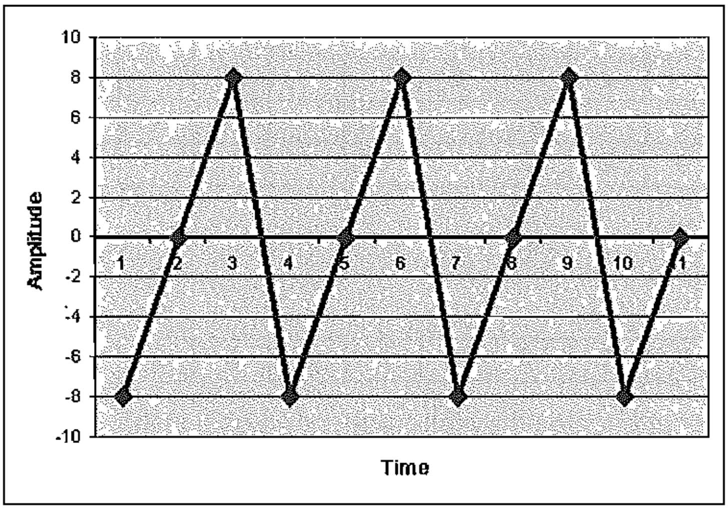


Figure 10.2: Graphic representation of a signal with a high frequency

1st data point:

−8	0	8	−8	0	8	−8	0	8	−8	0
*	*	*								
1/4	1/2	1/4								
−2	0	2								
	+									
	0									

2nd data point:

−8	0	8	−8	0	8	−8	0	8	−8	0
	*	*	*							
	1/4	1/2	1/4							
	0	4	−2							
		+								
	0	**2**								

3rd data point:

−8	0	8	−8	0	8	−8	0	8	−8	0
		*	*	*						
		1/4	1/2	1/4						
		2	−4	0						
			+							
	0	2	**−2**							

...

Result:

	0	2	−2	0	2	−2	0	2	−2	

The filter attenuates the high-frequency signal in this example by a factor of 4.

As a conclusion, this example is a low pass filter which allows low frequencies to pass through and attenuates high frequencies. The example is just for explanation purposes, in the software longer filters are used. The longer the filter, the steeper the edges in the filter characteristic function.

The examples also make the following properties of the selected filtering clear:

- The input and output signal are not shifted against each other in time, i.e. the phase is not affected.
- The output signal is shorter than the input signal by the filter length − 1.

For the output signal to have the desired length, the input signal has to be extended by the filter length − 1. This is done automatically by the software. The extended input signal can not be detected by the user, apart from a slightly longer measurement time. When using the trigger, the trigger time is adjusted so that it applies to the filtered signal. When using several channels with different filter settings, the software takes care that the time signals are synchronous.

Filter characteristic

The properties of the digital filters are shown in a filter characteristic diagram. Attenuation is plotted over the frequency. Attenuation of 0dB does not change the input signal. The range with 0dB attenuation is called the pass band. In the stop band, the input signal is attenuated by the stop band attenuation. Between the pass band and the stop band there is the transition band. The cutoff frequency selected by the user is approximately in the middle of the transition band.

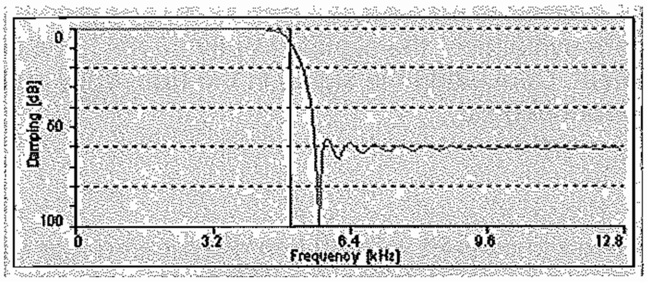


Figure 10.3: Filter characteristic

10.1.2 Filter Parameters

The following filter types are available:

- Low pass
- High pass
- Band-pass
- Band stop

The individual types are described below.

The parameter Quality affects both the length of the filters and also the approximate attenuation in the stop band. For illustration of the filter length the example filter [¼ | ½ | ¼] described above has a filter length of 3.

Quality	Length of filters	Stop band attenuation
very low	21	30dB
low	41	40dB
medium	61	50dB
high	81	60 dB
very high	101	70 dB

Low pass

Low pass filters allow low frequencies to pass and attenuate high frequencies.

High pass

High pass filters allow high frequencies to pass and attenuate low frequencies.

Band-pass

Band-pass filters allow medium frequencies to pass and attenuate high and low frequencies.

Band stop

Band stop filters allow low and high frequencies to pass and attenuate medium frequencies.

10.2 Filters for Integration or Differentiation

Filters for integration and differentiation are used to convert the input signals displacement, velocity and acceleration into each other. The same applies to angle, angular velocity and angular acceleration.

☞ When evaluating the spectrum, it is possible to convert the signal during analysis.

With a time data evaluation, the signal already needs to be converted during the measurement. Converting the signal in the frequency and time domain can show different effects.

10.2.1 Integration

Integration is used to convert velocity into displacement or acceleration into velocity. Integrating an acceleration signal twice to generate a displacement signal is not possible.

Operating principle

Integration is explained here using a velocity signal as an example which is converted into a displacement signal through integration. At the start of the time domain, it is arbitrarily defined that the displacement is to be zero. Therefore the first value of the displacement signal is 0. The second value of the displacement signal is determined by multiplying the first velocity value with the sample interval. The sample interval is the reciprocal of the sample frequency (sample interval = 1/sample frequency). The third value of the displacement signal is determined by multiplying the second velocity value with the sample interval and then adding the result to the second value of the displacement signal etc. The process is explained with the aid of FIGURE 10.4 and FIGURE 10.5.

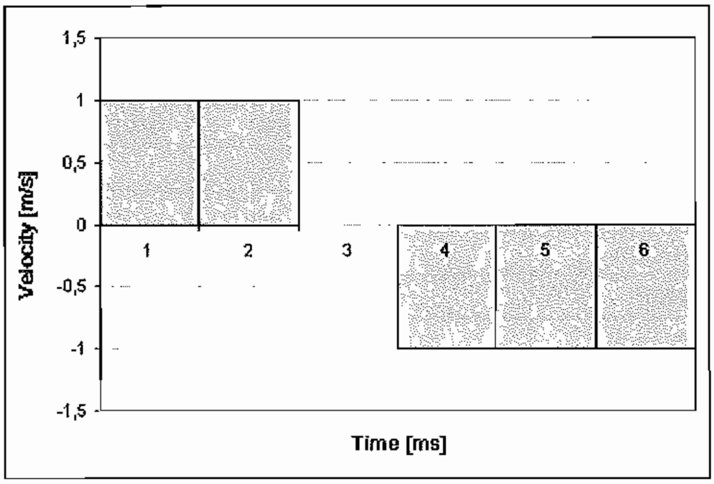


Figure 10.4: Measured velocity signal

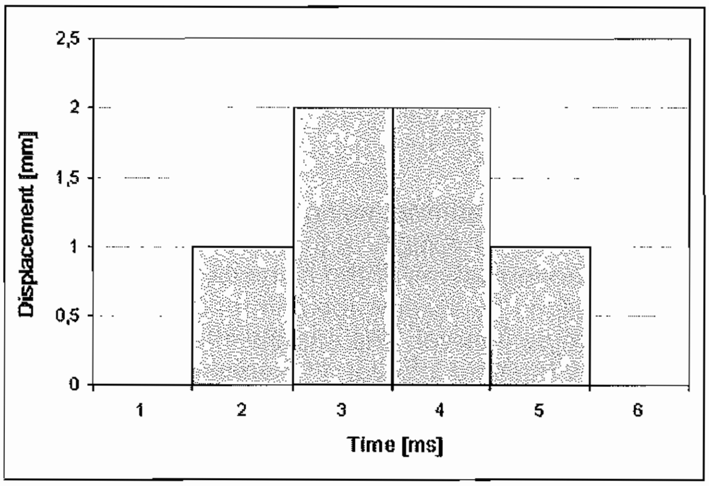


Figure 10.5: Calculated displacement signal

The displacement signal is generated, based on the assumption that the current velocity value remains unchanged until the next velocity value. In the case of constant velocity per section, it can be said that:

$$s_i = s_{i-1} + v \cdot \Delta t \qquad \text{Equation 10.1}$$

This assumption only leads to correct results with frequencies which are small in comparison to the sample frequency. In the case of frequencies which are nearly half the sample frequency, the approximation of a constant velocity per section can no longer be made. It would lead to errors of up to 30%. These errors are compensated for by a special FIR filter (refer to SECTION 10.1). For frequencies up to 40% of the sample frequency (equivalent to 80% of the bandwidth), the resulting error is less than 0.5%.

Properties

Integration in the time domain usually only works satisfactorily if the time signal does not have a DC offset. An offset causes a ramp in the integrated signal. This ramp is often undesired, in particular for low sample frequencies.

The offset in the time domain can be suppressed in many cases by inserting a high pass filter. However, it must be ensured that this does not cut off any portions of the wanted signal.

During integration, a time delay of half a sample interval occurs (sample interval = 1/sample frequency). This leads to a frequency-dependent phase shift.

☞ If the time signal in the time window is periodic and the signal does not have a DC offset, then the integration in the time domain corresponds to the integration in the frequency domain. Otherwise the two results do not match exactly.

An integrated time signal as a general rule shows a DC offset because the first time value is arbitrarily set to zero. Because integrating a time signal with DC offset does not give any meaningful results, the software does not offer double integration.

10.2.2 Differentiation

Differentiation is used to convert displacement into velocity or velocity into acceleration. By differentiating twice, displacement can be converted into acceleration.

Operating principle

Differentiation is explained here using a displacement signal as an example which is converted into a velocity signal through differentiation. From two respective neighboring values of the displacement signal, the average velocity is determined by dividing the difference between the displacement values by the sample interval. The sample interval is the reciprocal of the sample frequency (sample interval = 1/sample frequency). The process is explained by the aid of FIGURE 10.6 and FIGURE 10.7.

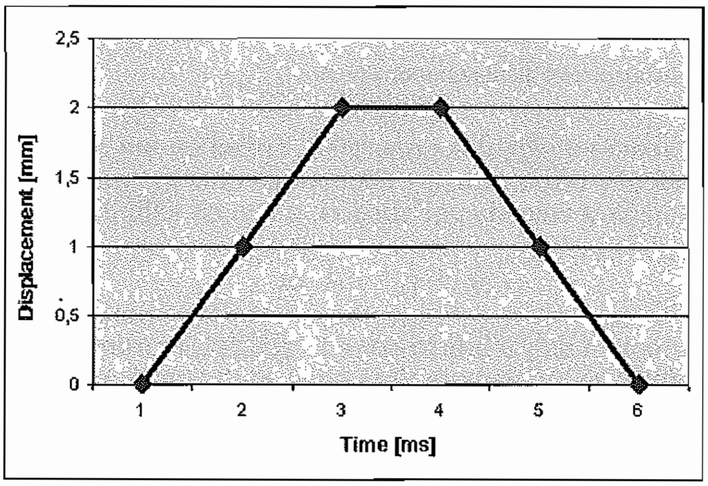


Figure 10.6: Measured displacement signal

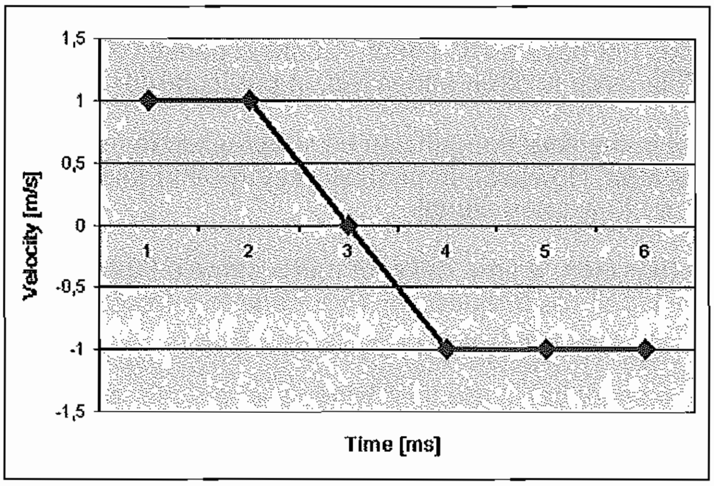


Figure 10.7: Calculated velocity signal

Thus it is presumed that the velocity between two neighboring samples is constant. In this case, it can be said:

$$v = (s_i - s_{i-1})/\Delta t \qquad \text{Equation 10.2}$$

This assumption leads to correct results only with frequencies which are small in comparison to the sample frequency. In the case of frequencies which are nearly half the sample frequency, the approximation of a constant velocity per section can no longer be made. It would lead to errors of up to 30%. These errors are compensated for by a special FIR filter (refer to SECTION 10.1). For frequencies up to 40% of the sample frequency (equivalent to 80% of the bandwidth), the resulting error is less than 0.5%. When differentiating twice, a maximum error of 1% can occur.

Properties

Differentiation in the time domain usually does not present any difficulties. Only a time delay of half a sample interval occurs during differentiation (sample interval = 1/sample frequency). This leads to a frequency-dependent phase shift.

☞ In the case of double differentiation there is no time delay. If the time signal is periodic in the time window, then the differentiation in the time domain corresponds to the differentiation in the frequency domain. Otherwise the two results do not match exactly.

11 Theoretical Background for PC-based Digital Demodulation (VDD)

In the sensor head a heterodyne interferometer generates a high-frequency carrier signal with the aid of a Bragg cell. For the digital demodulation, the carrier signal is converted into two quadrature signals I and Q in a mixing process. The quadrature signal pair carries the same information as the carrier signal, however it lies in the base band and is thus easy to process electronically.

Ideally the quadrature signals I and Q are sinusoidal, have the same amplitudes and are phase-shifted 90° apart. In FIGURE 11.1 we can see that in an I-Q diagram they depict a rotating pointer whose angle of rotation is equal to the interferometric phase difference $\Delta\varphi$. The sense of rotation corresponds to the direction of movement of the object under investigation.

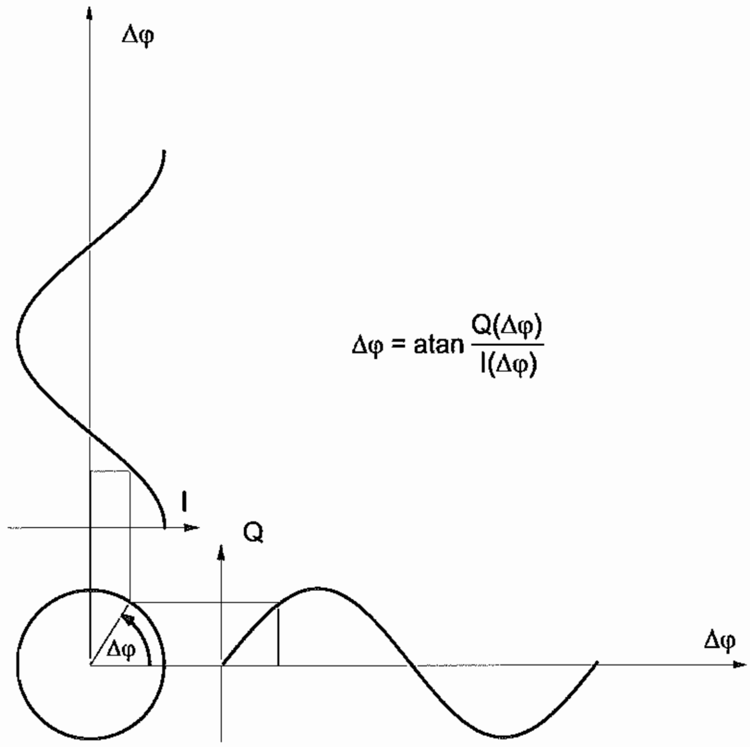


Figure 11.1: Graphical representation of the quadrature signals I and Q

The phase difference $\Delta\varphi$ is calculated using the following trigonometric relationships. We have

$$I(\Delta\varphi) = A\cos\Delta\varphi \quad \text{Equation 11.1}$$

$$Q(\Delta\varphi) = A\sin\Delta\varphi. \quad \text{Equation 11.2}$$

We divide equation 11.2 by 11.1 and obtain

$$\frac{Q(\Delta\varphi)}{I(\Delta\varphi)} = \frac{\sin\Delta\varphi}{\cos\Delta\varphi} = \tan\Delta\varphi. \qquad \text{Equation 11.3}$$

After applying the inverse tangent function we finally get

$$\Delta\varphi = \operatorname{atan}\frac{Q(\Delta\varphi)}{I(\Delta\varphi)}. \qquad \text{Equation 11.4}$$

The phase difference $\Delta\varphi$ is proportional to the displacement Δx of the object according to

$$\Delta\varphi = \frac{4\pi}{\lambda}\Delta x. \qquad \text{Equation 11.5}$$

In practice it is important to generate the quadrature signals with a high level of stability and spectral purity. Furthermore a suitable A/D converter is required to sample both the quadrature signals with sufficient resolution. After sampling, the remaining errors – which are mainly caused by the analog components in the mixing process – are corrected using special algorithms.

12 Working Efficiently with the PSV

This chapter explains how

- the PSV records measurement data of a vibrating system,
- you can optimize the measurement setup,
- you select suitable settings for your measurement.

12.1 Recording Measurement Data in a Vibrating System

A typical measurement setup with the PSV is shown in FIGURE 12.1.

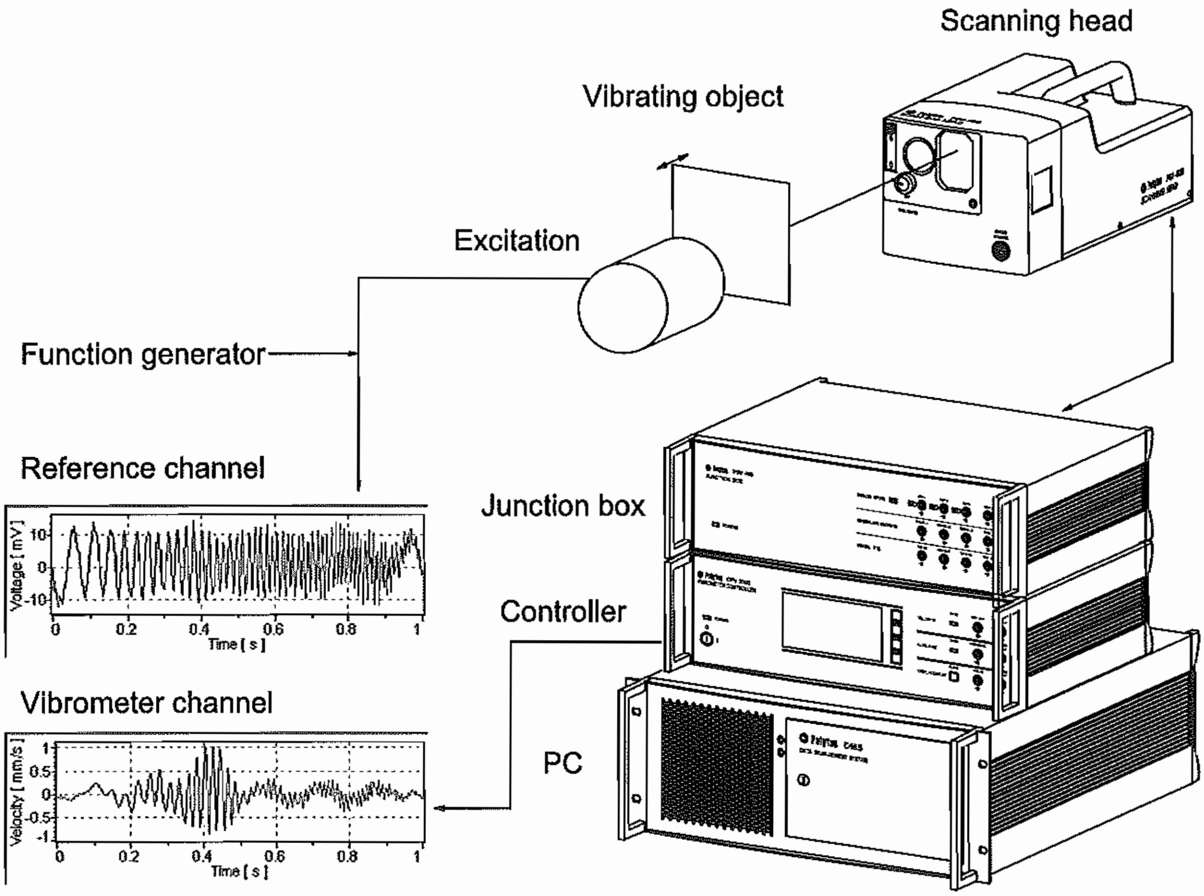


Figure 12.1: Principle of data recording with the PSV

- An excitation (shaker, loudspeaker, hammer etc.) causes the object under investigation to vibrate.
- The measurement beam from the interferometer in the scanning head is positioned to a scan point on the object by means of mirrors and is scattered back.
- The backscattered laser light interferes with the reference beam in the scanning head.
- A photo detector records the interference.
- A decoder in the controller provides a voltage which is proportional to the velocity of the vibration parallel to the measurement beam.

- The voltage is digitized and processed as vibrometer signal.

It is important to select the kind of excitation which allows you to receive the best results for your measurement task. The type of excitation also decides on the measurement parameters. There are the following types of excitation:

- Periodic i.e. with a repeating signal (sinusoidal vibration, periodic chirp, pseudo random, etc.)
- Transient i.e. with a pulse (e.g. rectangular pulse, hammer blow etc.)
- Stochastic (random) i.e. with noise (e.g. noise generator, self-excited)

You can use the excitation as a reference signal or for triggering. You can also use the excitation force measured by a force cell as a reference signal. The reference signal is processed in the same way as the vibrometer signal.

12.2 Optimizing the Measurement Setup

Position the scanning head

The PSV measures velocity components parallel to the laser beam. Position scanning head and object such that

- the laser beam can cover the complete area to be scanned,
- the front panel of the scanning head and the center of the area to be scanned are located opposite each other,
- the longitudinal axis of the scanning head is positioned perpendicular to the area to be scanned.

Optimize the signal level

Test the vibrometer signal level (in the scanning head control) at several scan points, especially at scan points with unfavorable backscattering behavior. The higher the level, the better the signal-to-noise ratio will be. The PSV often also provides useful measurement results at low levels.

If the vibrometer signal level is too low:

1. Check the focus of the laser beam.

   Use Assign Focus during Scan if one focus value does not apply for all scan points.

Check the distance between the front panel of the scanning head and the measured object:

2. Increase the distance if the laser beam hits the lateral points of the scan field at a great angle.

3. Try to place the object in a maximum of the laser intensity. The distances between the maxima are 204mm (= length of the laser resonator). In between there are minima of the laser intensity where strong temporal fluctuations of the signal intensity can appear. You will find more detailed information on visibility maxima in your hardware manual.

4. If necessary, treat the surface of the area to be scanned. Highly reflective and transparent surfaces usually do not scatter enough laser light back to the scanning head. Evenly matt surfaces are ideal, as for example achieved by means of a sandblaster. A useful tip is to cover a large object with a coat of paint using water-soluble white wall paint or Spanish white. You can also use Ardrox developer spray or reflective film.

12.3 Optimizing Resolution and Measurement Time

The total time needed for a scan is:

$$t_T = t_W \cdot n_p \cdot n_a + t_{add} \qquad \text{Equation 12.1}$$

t_T...Total time for a scan

t_W...Length of the time window

n_p...Number of scan points

n_a...Number of averages

t_{add}...Additional times

Additional times for a scan are, for example

- time to wait for a trigger,
- time for remeasurement,
- time for waiting until the scanner mirrors are at rest,
- time for updating measurement data in analyzers,
- computing time.

You can optimize the resolution and the time needed for a scan as follows:

1. Select a sufficient number of FFT lines to obtain an appropriate number of frequency values in the set bandwidth.
2. Select the number of scan points according to the size and structure of your scan field.
3. Select the number of averages depending on the noise level.
4. Select Overlap if available (refer to SECTION 12.6).
5. Avoid triggering if possible.
6. Close analyzers which you do not need.

12.4 Noise Reduction with the Tracking Filter

The following applies only for analog velocity decoders: When using the digital velocity decoder VD-07/VD-08, the tracking filter does not have any effect.

Principle

It is important to select a suitable tracking filter setting (dialog Acquisition Settings, page Vibrometer). Due to physical principles (speckle effect), the back scattered laser light can intermit for a short time. The tracking filter bypasses these intermittences and decreases the noise of the input signal according to the PLL Principle (Phase Locked Loop).

If the tracking filter is activated, an oscillator is coupled to the input signal. The oscillator has the effect of a flywheel.

The oscillator follows the input signal

- if velocities and accelerations which are not too high appear on the scan field. The acceleration is proportional to the product of velocity and frequency of the measured vibration.
- if the input signal only intermits for a short period only.

The oscillator does not follow the input signal and the output signal is of no use

- if very high velocities and accelerations appear on the scan field.
- if the input signal intermits for a long period.

Settings

You will find detailed information on selecting suitable tracking filter settings in your hardware manual.

12.5 Optimizing Input Signals with Signal Enhancement and Speckle Tracking

For a scan it is desirable to achieve similar signal quality - i.e. similar noise level – for all scan points. This is, however, made difficult by two problems:

- The speckle nature of the back scattered light
- Differing surface qualities, curved surfaces as well as varying distances for different scan points

The functions Signal Enhancement and Speckle Tracking (dialog Acquisition Settings, page SE) remedy or reduce these problems. This is achieved as follows:

- The noise level is estimated for each individual measurement. In the PSV-3D the worst noise level in the Cartesian coordinate directions x, y, or z is used for the estimate. If averaging is switched on (page General), the individual measurements are averaged and weighted according to their noise level. Measurements with low noise level are weighted higher. The noise level of the averaged spectrum is estimated.

- During a scan the noise level of each scan point is compared with previous scan points. If the noise level is relatively high, additional averages are carried out until the typical noise level is achieved (up to five times the manually set averages). If speckle tracking is activated, the position of the beam is slightly altered (typically 50 µm at 1 m stand-off distance) between the individual measurements. At the end of this procedure a scan point with a relatively low noise level receives the status Optimal. Other scan points receive the status Valid.
- At the end of a scan the signal quality of all scan points is compared. Few scan points may change their status.

With Remeasure activated on the page General, all non-optimal scan points are automatically remeasured (up to ten times) after a scan is finished. The remeasurement starts at scan points with a noise level immediate to optimal scan points.

☞ You can stop a measurement any time. Stopped measurements are evaluated and saved in exactly the same way as completed measurements.

12.6 Overlap

For PSV-3D, PSV 400-B and -H4 (also PSV 300-U and -H) in the measurement modes FFT and Zoom FFT you can set overlap (dialog Acquisition Settings, page Frequency). The software only takes the parameter into account for measurements with averaging and without trigger. With overlap, the software evaluates the data more effectively. For small bandwidths the time needed for a measurement can thus be reduced.

Principle

The measured time signal is cut into blocks for the FFT. With an overlap of zero, the blocks are right next to each other. If the value is greater than zero, the blocks overlap by this amount. Thus the software records less samples for a measurement.

Example

The following settings have been selected:

- 3 averages
- 100 FFT lines, i.e. 256 samples per block.

The software calculates the FFT for this measurement from the blocks as detailed in TABLE 12.1.

Table 12.1: Calculation of FFT blocks with and without overlap

FFT	Without overlap	With 50 % overlap
1st block	1st to 256th sample	1st to 256th sample
2nd block	257th to 512th sample	129th to 384th sample
3rd block	513th to 768th sample	257th to 512th sample

In this example, only 512 Samples are acquired with 50% overlap instead of 768 Samples without overlap.

If you are measuring with overlap, pay attention to the following:

- The noise reducing effect of the averaging is less, particularly if you use the window function Rectangle or Tapered Hanning.
- For bandwidths above approximately 5 kHz, the time for a measurement is determined by the computing time. In this case, overlap does not give you a time advantage.
- If Signal Enhancement is active, the probability of getting more scan points with the status Optimal in the same time is higher. The best setting in this case is 50% overlap and twice the number of averages than you would set without overlap.

12.7 Selecting a Reference and Trigger

If possible, you should always measure with a reference signal or trigger. Then you obtain useful phase information.

The phase relation of the vibrometer signal to the excitation is normally not constant at the individual scan points, but depends on the location of the scan points. Therefore the vibrometer signal must not be used as a trigger.

Reference

As a reference signal, you can use the excitation of the vibration, for example.

Trigger

As a trigger, you can use

- the excitation itself,
- a periodic or transient signal that comes form the object and that is in a fixed phase relation with the excitation.

If the message NO TRIGGER appears in the status bar, the trigger signal is either missing or below the threshold (value in Level, dialog Acquisition Settings, page Trigger).

1. Check in an analyzer the signal on which you are triggering.

2. Adapt the level to the signal with which you are triggering.

The phase of the vibrometer signal is calculated by different methods, according to the measured channel, averaging and trigger as detailed in TABLE 12.2.

Table 12.2: Calculation of the vibrometer signal

Averaging	Trigger	Ref available	Phase Vibrometer (V)	Phase Reference (R)
Off	Off	No	0	not available
Off	Off	Yes	Phase V referred to phase R	0
Off	On	No	Phase V referred to start of time window	not available
Off	On	Yes	Phase V referred to start of time window	Phase R referred to start of time window
Magnitude	Off	No	0	not available
Magnitude	Off	Yes	Phase R*V (crosspower spectrum) assigned after averaging	0
Magnitude	On	No	0	not available
Magnitude	On	Yes	Phase R*V (crosspower spectrum) assigned after averaging	0
Complex	Off	No	settings not possible	settings not possible
Complex	Off	Yes	Phase V referred to phase R prior to averaging	0
Complex	On	No	Phase V referred to start of time window	not available
Complex	On	Yes	Phase V referred to start of time window	Phase R referred to start of time window

See SECTION 6.3 and SECTION 6.4 for more details.

12.8 Windowing

The most important parameters to distinguish between the window functions are:

- Maximum amplitude error (ripple)
- Highest side lobe attenuation
- Roll-off rate
- Increase of the resolution bandwidth.

In TABLE 12.3 a summary of the values for these parameters is shown. You will find a detailed description of the parameters and also general information on windowing and the various window functions in CHAPTER 5.

Table 12.3: Parameters for window functions

Window function	Max. amplitude error %	Highest side lobe attenuation dB	Roll-off rate dB/dec	Increase of the resolution bandwidth
Rectangle	-36	13	20	1.00
Hanning	-15	32	60	1.50
Hamming	-18	43	20	1.36
Blackman	-12	58	60	1.73
Blackman Harris	-9	92	20	2.00
Bartlett (triangle)	-19	27	40	1.33
Flat Top	-0.2	68	20	3.77
Tapered Hanning (Parameter=10)	-35	12	20	1.08

The **exponential window** has not been included in TABLE 12.3 as it is not suitable for windowing continuous signals. It is used for impulse excitation if the answer signal does not decay in the time window. An important parameter for the exponential window is the time constant which can be set in the software.

13 Working with 3D Geometries

The PSV Software supports three dimensional geometries for the scan points. This means that in addition to the two dimensional position on the live video image a three dimensional coordinate in space is assigned to every scan point. After the vibration data has been measured at the scan points it can be displayed on the three dimensional geometry of the object under investigation.

13.1 Why Using a 3D Geometry?

For PSV-3D systems using 3D geometry is mandatory. The software needs to know the positions of the three scanning heads in the coordinate system of the object under investigation to be able to calculate the directions of the laser beams at the current scan point. Only with this information the vibration components measured in the directions of the laser beams can be transformed to 3D data with the vibration components in x, y and z direction.

When using a 3D geometry the software knows the position of the scanning head in the coordinate system of the object under investigation. For every individual scan point the distance to the scanning head can be calculated. This can be used by the PSV software to automatically focus the laser beam at the current scan point. Before, select Scan > Assign Focus Fast in acquisition mode.

Knowing the position of the scanning head and the 3D coordinates of the scan points allows for calculating the scanning mirror angles such that the laser beam precisely hits the scan points in space. Especially for objects that are not flat but quite deep this method is superior to the method used to position the laser beam by using the positions on the live video image.

If you want to measure at nodes for example of a finite element model of your object you can import the coordinates of the nodes into the PSV software and measure exactly at these points. Comparing measurement results with calculation results of the finite element software becomes much easier when you use the same positions of the scan points and the finite element nodes.

Using a common 3D coordinate system for a sequence of measurements from different positions and/or directions of the scanning head allows for combining the measurement results into a single result on the combined geometry of the object under investigation.

13.2 Alignment Methods

The laser beam is deflected in the scanning head by mirrors controlled by the PSV software. There are two different procedures that allow for positioning the laser beam on the scan points: standard alignment (2D) and 3D alignment. Both methods allow to calculate the mirror angles for a given scan point either from its position on the live video image (standard alignment) or from its 3D coordinates (3D alignment).

Standard alignment (2D)

Using this function the software can position the laser beam if you click on a position on the live video image. Moreover the laser beam is able to follow the mouse cursor. Scan points can be defined on the live video image.

During standard alignment a sequence of positions of the laser beam are marked on the live video image. After setting an alignment point at the laser spot on the live video image, the beam is moved to a different position and the next alignment point is marked by clicking the position. During this process the software stores a pair of values for every alignment point: the position on the live video image (expressed in video coordinates) and the angles of the horizontal and vertical scanning mirrors. From these pairs of values the software calculates the parameters of a regression function that maps video coordinates to angles and vice versa.

For three dimensional objects this works well only if the camera is positioned very near to the scanning mirrors compared to the distance to the object. Otherwise the different view positions of scanning head and camera lead to parallax effects that can not be compensated by the standard alignment function. For objects on which not all points have the same distance to the scanning head, deviations between the point marked on the live video image and the laser position can occur. Those deviations become larger with greater depth of the object and shorter distance between object and scanning head. They can be avoided using the coaxial unit for the scanning head.

For the PSV-3D the camera used is not parallel to all of the scanning heads. Therefore, the deviations between the point marked on the live video image and the laser position are generally larger. In order to increase the accuracy for the PSV-3D, higher order polynomials are used to calculate the regression if at least 10 points are used for the standard alignment.

3D alignment

Using the 3D alignment, the software can calculate the mirror angles that let the laser beam hit a point in space from the 3D coordinate of this point. This is used by the software during a scan to position the laser beam to points with known 3D coordinates.

During 3D alignment at least 3 alignment points with known distances to the scanning head or at least 4 alignment points for which the distances are not known are used. For every alignment point the 3D coordinates have to be known. The coordinate system of these points defines the coordinate system of the object under investigation (object system). Together with the mirror angles that let the laser beam hit the alignment points, the software calculates the position and direction of the scanning head in the object system.

With the optional geometry scan unit the software is able to measure the distance to the point on the object, where the laser points to. This is used during 3D alignment to measure coordinates of alignment points of a defined type (e.g. origin of the object system, point on a coordinate axis, etc.).

13.3 Coordinate Systems

Video coordinates

The video coordinate system is used to place the scan points on the live video image in acquisition mode and on the video snapshot in presentation mode. The video coordinate system is used internally only.

Scanning head system

The scanning head system is a Cartesian coordinate system. The origin of this system is the position where the laser beam with 0°/0° mirror angles would hit the front panel of the scanning head. The orientation of the coordinate system depends on the setting of the direction of the vibrometer channel on the page Channels in the dialog Acquisition Settings. The different orientations of the coordinate axes are summarized in the following table.

Vib Direction	x-axis	y-axis	z-axis
+X	to head	up	to the left
+Y	to the right	to head	down
+Z	to the right	up	to head
–X	from head	up	to the right
–Y	to the right	from head	up
–Z	to the left	up	from head

The scanning head system is used if no 3D coordinates are known for the scan points. In this case, you can enter the distance to the object under investigation and the software will calculate the x-, y- and z-coordinates of the scan points from the mirror angles assuming that all scan points are placed on a plane perpendicular to the 0°/0° direction of the laser beam placed at the given distance to the scanning head. As the origin of the scanning head system is placed on the front panel of the scanning head, all scan points will have either the same x-, y- or z-coordinate, depending on the orientation of the coordinate system and therefore on the direction of the vibrometer channel. These 3D coordinates will be displayed for the selected scan point in acquisition and presentation mode below the element 2D Point.

During export of the scan point coordinates to Universal File format, ME'Scope structure files or ASCII files these coordinates will be used as 3D coordinates of the scan points. The coordinate that is equal to the distance to the scanning head will be set to 0 during export for all scan points.

Object system

The object system is the Cartesian coordinate system used for the alignment points during 3D alignment. The coordinates of the alignment points define the object system.

During import of 3D geometries from Universal File format, ASCII format or ME'Scope structure files the 3D coordinates will be interpreted to be in the object system of the current 3D alignment.

During a geometry scan the measured 3D coordinates will be measured in the object system. Therefore you need a valid 3D alignment to perform a geometry scan.

In APS point mode, you can define single scan points. The 3D coordinates are either calculated by measuring the distance to the scan point with the geometry scan unit or via triangulation of the three laser beams that hit this point (only possible with PSV-3D). In both cases, the object system will be used for the 3D coordinates of the defined scan points. Therefore you have to have a valid 3D alignment to define points with 3D coordinates.

The 3D coordinates of the scan points will be displayed in the object system below the element 3D Point when you select a scan point in acquisition or presentation mode. These coordinates will be used during export to Universal files, ME'Scope structure files and ASCII files without further modification.

13.4 Sources of a 3D Geometry

This section describes the different methods for getting a 3D geometry into the PSV software. Every method has its special advantages and drawbacks: Knowing them, you can choose the method suited best for your needs.

Import of geometry data (PSV-3D, optional for PSV-1D)

If you have a valid 3D alignment, i.e. if you have defined an object coordinate system, you can import geometries from Universal File format or ASCII format geometry files or from Vibrant's ME'Scope structure files. To do so, change to APS point mode and click [icon] or in the menu bar select Scan > Import Geometry. You can then navigate to the geometry file and import the geometry from this file.

The geometry definition files contain the 3D coordinates of a set of measurement points and only for Universal File format or ME'Scope structure files lists of connections between these points defining surface and line elements of the geometry. The latter are used to display a surface of the object under investigation in presentation mode.

The 3D coordinates of the measurement points have to correspond to the coordinate system that you have used during 3D alignment. With the 3D alignment the software can position the laser beam to hit the measurement points. The precision of the laser position depends mainly on the quality of the 3D alignment.

The measurement points will be placed on the live video image using the standard alignment. These positions are used for displaying purposes only, they do not influence in any way the measurement results. The precision of the measurement point positions on the live video image (i.e. how well the points are positioned on the corresponding laser spots) depends on the quality of the standard alignment. For deep objects or if the camera position is not at the position of the scanning head (e.g. if you use the center camera of PSV-3D), the quality of the standard alignment might not be satisfactory. The software offers to correct the positions on the live video image automatically. To do so, the software successively positions the laser to every measurement point using the 3D alignment and tries to find the laser spot on the live video image. If it succeeds, this position will be used instead of the position calculated via the standard alignment.

☞ Please pay attention that during this action no movement should occur in the live video image. Keep the personal from walking through the field of view.

The imported geometry might be larger than the range that can be covered by the live video image and/or the range of the scanning mirrors. Nevertheless, the software will import the complete geometry, placing the points on the live video image if possible. The other points will be visible around the zoomed out live video image. The software marks the points that can not be reached by the scanning mirrors with a color code. These not reachable points will be excluded from the scan automatically. If points are hidden by any parts of the object under investigation, i.e. if there is no direct line of sight from all scanning heads, these points are marked with a different color code. These hidden points will be scanned after a warning message.

Once you have imported a geometry you are free to edit it. You can delete or add points (adding with PSV-1D needs the geometry scan unit) or modify the connections between the points. You can move points around on the live video image and you can modify the 3D coordinates of the selected points to optimize how well the three lasers hit the same point on the object under investigation.

Triangulation (PSV-3D only)

If you define your geometry in APS standard or point mode, the PSV software at first has information on the positions of the measurement points on the live video image only. For PSV-3D it is mandatory to have 3D coordinates for the measurement points. Therefore, the software calculates the 3D coordinates from the positions on the live video image by a method called triangulation. Using the standard alignment for all three scanning heads (Top, Left and Right), the scanning mirror angles for every scanning head and for every scan point are calculated. From the scanning head positions and orientations known from the 3D alignment the software calculates the laser beam paths for every scanning head. The 3D coordinate of the point in space where these three beams come closest to each other is used as the 3D coordinate of the respective scan point.

As triangulation uses the standard alignment which is not precise in all cases, the 3D coordinates calculated by this method might not be precise enough. To check this, you can select the scan points one after the other and check if the laser spots hit the object under investigation at the same spot and at the desired position. Here the 3D alignment is used to calculate the mirror angles from the 3D coordinate. These mirror angles are slightly different to the mirror angles calculated from the standard alignment before.

Modify 3D coordinates

To modify the 3D coordinates, you can select a single or more points and right click one of the selected points. Select Modify 3D Coordinates in the pop-up menu. The dialog Modify 3D Coordinates appears where you can modify the 3D coordinates of the selected points by changing the coordinates directly or by a slider. Moving the slider will move the 3D coordinate along the direction of the laser beam path. For the PSV-3D the 3D coordinate is moved on a line that corresponds to the average direction of the three laser beam paths. You can use the slider to minimize the distance between the laser spots on the object under investigation. All 3D coordinates of all selected points will be changed by the same amount when closing the dialog.

Geometry scan unit (PSV-3D, optional for PSV-1D)

With the geometry scan unit PSV-A-420 that is attached to the PSV-I-400 scanning head, the software can measure distances from the scanning head to any point on the object under investigation that can be reached by the laser. The geometry scan unit contains a laser with a microcontroller that allows for measuring distances. The laser is fed through the optics of the scanning head such that the same scanning mirrors are used to position the geometry laser and the vibrometer laser. The scanning head optics is aligned so that the laser spot of the geometry laser hits the same point on the object under investigation as the vibrometer laser if the same scanning mirror angles are used. You can switch between the two lasers any time in the software by selecting Scan > Geometry Laser. In addition you can move a filter into the optical path of the geometry laser either by using the mechanical switch at the geometry scan unit or by activating the check box Filter in the scanning head control of the software (depends on the version of the geometry scan unit). This can be used to dim the geometry laser if too much light is scattered back from the object which can overexpose the sensor of the geometry scan unit.

While the geometry laser is active, you will see a signal strength indicator for the geometry laser in the scanning head control. It is recommended that you check the signal strength for the part of the object under investigation that you want to scan. The indicator should show some signal strength and the LED OVER should be green. If applicable, modify either the filter setting or change the distance of the scanning head to the object. As you might have to change the distance of the scanning head to the object, do this before you perform the standard or 3D alignment because otherwise you would have to repeat the alignments. You can move the laser without a valid standard alignment either with the icons Position in the scanning head control or by pressing and holding down the middle mouse button (mouse wheel) while moving the mouse.

☞ If the measured distance is about 2 m, the sensitivity of the geometry laser has a minimum. In order to increase the signal strength, the scanning head can be moved to a shorter or larger distance (this applies only if the filter switch is on the geometry scan unit).

Using the PSV software you can perform a geometry scan. First you have to perform a standard alignment, so that the software can position the laser using the position of the measurement points on the live video image. Then you have to perform a 3D alignment to define the object coordinate system that is used for the 3D coordinates measured during the geometry scan. After this you can define your geometry as usual using one of the APS modes. Having left APS mode, you can start the geometry scan. To do so, select Scan > Geometry Scan. Note that this command is only enabled if you have a valid standard and 3D alignment. The coordinate system of the 3D coordinates is defined by the coordinate system of the alignment points of the 3D alignment (object system).

If you want to check the distance measurement at some points before performing the geometry scan, position the laser to the desired points and select Scan > Geometry Point. The software will measure the distance to the point on the object under investigation and display a dialog were you can read the measured distance and the 3D coordinate of the point in the object system.

During the geometry scan the software positions the geometry laser beam to the scan points calculating the scanning mirror angles from the positions of the scan points on the live video image using the standard alignment. Therefore the precision on how well the positions on the live video image match to the positions on the object depends on the quality of the standard alignment.

☞ If you are using a PSV-3D system, we recommend using the video camera of the scanning head Top to display the live video image because this allows for higher quality in the standard alignment of the scanning head Top which is used for the geometry scan.

If the distance measurement fails for some scan points, the software will display a message and offers to repeat the measurement or interpolate the coordinates for the remaining points. During interpolation the distance of a scan point is interpolated from the distances of the neighbors of this point. Then the coordinate is calculated from this distance and the position of the point on the video image. If the point has no neighbors with coordinates, the coordinate remains unmeasured and the dialog is displayed again. If you click Cancel in this dialog, the remaining points will receive the point status No 3D coordinate.

The distance measurement might fail for the following reasons:

- There is too much light scattered back to the geometry scan unit. You can switch the filter of the geometry scan unit on before repeating the geometry scan for the remaining points (only if the filter switch is on the geometry scan unit).
- There is too little light scattered back to the geometry scan unit. You can switch the filter of the geometry scan unit off before repeating the geometry scan for the remaining points (only if the filter switch is on the geometry scan unit).
- If the amount of light is still too much or little after applying/removing the filter, you can try to paint the object, attach a piece of paper to it or find some other means to change the reflective properties of the object's surface. You might even want to remove the specific points from your geometry by converting the geometry to a point geometry and edit it in APS point mode. Repeat the geometry scan after you have done this.
- Not the whole laser spot hits a single part of the object. You might want to convert your geometry to a point geometry by entering the APS point mode and move this point. Then repeat the geometry scan.

If you want to add or remove some points of the geometry you can switch to APS point mode. This will keep the 3D coordinates of the points. You can add new points by positioning the laser on the object and click ⁺⁺⁺ or select Scan > Point at Laser Position. The software will automatically perform a distance measurement to this point, calculate the corresponding 3D coordinate and add the point to the geometry.

13.5 3D Geometry and Vibration Data

After you have acquired a 3D geometry you can perform a vibration measurement at the defined scan points. The software will position the vibrometer laser to the measurement points by calculating the scanning mirror angles from 3D coordinates via the 3D alignment. After that you can switch to presentation mode and analyze the vibration data.

There is a 2D and a 3D mode to display the data. In 2D mode the geometry and measurement results are displayed on the live video snapshot taken at the beginning of the vibration measurement scan. You can use color-coding and different view styles to analyze the vibration data.

In 3D mode the vibration data is displayed on a projection of the 3D geometry. Using a virtual camera, the 3D geometry is projected to the view area of the presentation window. By using the mouse and other controls of the software you can move the camera around the object and get an impression of the geometry from different view angles.

In addition to color-coding on the surface of the object, the vibration data is displayed as displacement from the zero position of the geometry. The 3D geometry is deformed by the vibration data. You can display the zero position together with the deformed geometry of the vibration data. To do so, mark the box Zero Position on the page 3D View in the dialog Display Properties.

During phase animation, the instantaneous values are calculated and the deformed geometry and color-coding are updated accordingly. During time domain animation the deformed geometry and color-coding are updated according to the measurement values corresponding to the current time after trigger.

Please note that the displacements used to visualize the vibration data do not represent real displacements of the object under investigation. You can not only visualize displacement data like this but also data in other physical units like velocity, acceleration or FRFs. Even when you display displacement data the displacement in general is exaggerated by a large number of orders of magnitude. The PSV usually measures displacements in the µm range that are displayed as displacements in the m range.

Visualize one dimensional data (PSV)

The geometry is deformed along the coordinate axis, that corresponds to the direction of the acquisition channel. If e.g. the direction of the channel is –X then positive values are displayed as displacement along the negative x-coordinate axis and negative values along the positive x-coordinate axis. If the vibrometer channel direction is +Z then positive values are displayed along the positive z-coordinate axis and negative values along the negative z-coordinate axis.

☞ An angle correction is available to correct the measured vibration data for the incident angle of the laser beam at the surface of the object under investigation, because the vibrometer measures the vibration component along the laser direction. On the page Scanning Head of the dialog Preferences you can activate a correction for the horizontal and vertical scanning directions. The algorithm used for this assumes a planar object surface perpendicular to the 0°/0° direction of the laser beam and a pure out-of-plane vibration. If this is a bad approximation to your object under investigation, you might consider to switch off the angle correction altogether, displaying the uncorrected vibration component along the laser beam.

Visualize three dimensional data (PSV-3D)

For three dimensional data measured with the PSV-3D the color codes correspond to the value

$$A = \sqrt{A_x^2 + A_y^2 + A_z^2} \qquad \text{Equation 13.1}$$

where A_x, A_y and A_z correspond to the components measured in the corresponding coordinate axis directions of the object coordinate system. You can switch off any combination of components by deselecting the corresponding icons in the toolbar of the presentation window. In this case the corresponding colors are calculated from the remaining active components only. All displayed values are positive, as can bee seen from equation 13.1. The phase display is not available for 3D data. To display single direction components with sign information or phase, switch to 2D display mode and select the corresponding vibrometer channel Vib X, Vib Y or Vib Z.

The position of the deformed geometry is calculated from the individual A_x, A_y and A_z components by adding the scaled components with sign information to the 3D coordinate of the measurement point. Note that only those components are taken into account, that are active. It is not possible to display values that are positive or negative only as a deformed geometry, e.g. it is not possible to display magnitude, magnitude dB or magnitude dB(A) as deformed geometry, because those would be displayed as a misleading displacement towards the positive or negative coordinate axes only.

13.6 Best Practices

This section provides a list of practices that you might find useful when you are working with 3D geometries.

To set up the measurement, proceed as follows:

1. Check the signal strength of the geometry laser.
2. Carry out a standard alignment.
3. Carry out a 3D alignment.
4. Define the geometry.
5. Make a geometry scan.
6. Select Scan > Assign Focus Fast.
7. Make a vibration measurement scan.

If you have a 3D geometry, using Assign Focus Fast is the best choice. As the software knows the distances to all scan points it is enough to determine the laser focus values at a very small number of scan points and interpolate the rest of the focus values using the known distances. In case of a 3D geometry the Assign Focus Fast method is as good as Assign Focus Best for nearly all practical situations but it is much quicker.

If the Assign Focus Fast command fails, you might want to exclude scan points from being used for the algorithm. To do this, disable these scan points by selecting them, right click one of them and select Disable in the pop-up menu. The Assign Focus Fast algorithm will then only use the points that are not disabled. Nevertheless, if it succeeds, the determined laser focus values are assigned to all points, including the disabled points. Enable the points you have disabled again, so that they are included in the measurement.

If you are using the geometry scan unit with the PSV-3D, use the video camera in the scanning head Top to perform the standard alignment. This minimizes effects caused by the different view directions and positions of the camera and the scanning head that can not be fully compensated by the standard alignment for deep objects. A better standard alignment quality allows for a better match of the measurement point positions on the live video image to the measurement points on the object.

If your object under investigation is too large to be scanned from a single position of the scanning heads or if you want to scan different sides of the object, you can stitch a sequence of measurements. In this case, you have to use a common coordinate system for all measurements, i.e. the reference points of all 3D alignments have to be defined in the very same coordinate system. To achieve this, proceed as follows:

1. Open the page Devices in the Preferences dialog and select the junction box PSV-E-400-3D (1D).
2. Open the page Channels in the Acquisition Settings dialog and deactivate the channels Vibrometer Left and Vibrometer Right.

3. Position the scanning head Top with the geometry scan unit attached at a position where you have a direct line of sight to a large part of your object under investigation.

4. Perform a standard and 3D alignment for the scanning head Top only. For the 3D alignment either use reference points that you have determined before (see below) or define your object coordinate system with one of the coordinate definition modes of the 3D alignment. Use the geometry scan unit during alignment.

5. Mark reference points on the object under investigation. Mark the points with a unique number. For every position of the scanning heads during the later measurements, you have to have at least four reference points that can be directly reached by all scanning heads from their position. It is recommended to use at least five points for optimal quality of the alignment.

6. Switch to APS Point Mode and define scan points at the reference points. Position the laser of the Top scanning head on the reference points and use the command Point at Laser Position at every reference point. Make sure that the indices of the points match those of the marks on the object under investigation. You can change the indices of the points, if necessary. The position of the points on the live video image will not be used, only the 3D coordinates of the points are important.

7. Repeat steps 3 to 6 until you have reference points on all parts of the object under investigation that you want to scan. When you change the 3D alignment in step 4, the software will ask you if the scan point positions on the live video image should be recalculated. Click No, because in this case the positions are irrelevant. You can even move the points out of the way on the live video, if you want to. This will not change the 3D coordinates of the points. When you perform the 3D alignment select the Points with free Coordinates mode and use reference points with known coordinates.

8. Leave APS Point Mode and export the scan points to a Universal file. To do so, in acquisition mode, select File > Export > Universal File.

9. Open the page Devices in the Preferences dialog and select the junction box PSV-E-400-3D.

10. Position all scanning heads for the first measurement.

11. Open the dialog 3D Alignment. Deactivate the box Auto. Import the coordinates of the reference points by clicking Import. A list of the reference points with their unique numbers and their coordinates will be imported into the table at the lower part of the 3D Alignment dialog.

12. Define a new alignment point at one of the reference points marked on the object under investigation. Position all laser beams on this point and assign the laser positions to the alignment point.

13. Select the reference point in the coordinate list and assign its 3D coordinate to the alignment point. Use the unique number of the reference point to identify the entry in the list.

14. Repeat steps 12 and 13 for more reference points.

15. Calculate the 3D alignment, define the geometry and perform the scan.

16. Repeat steps 10 to 15 for all measurements in the measurement sequence

17. Change to presentation mode and stitch all measurements by creating a new combined file.

If the coordinate definition modes available during 3D alignment with the geometry scan unit do not suite your needs, you might want to do the following: Start with either Origin, Axis, Plane or Three Points on Axes by defining the alignment points. Calculate the 3D alignment. This will enter the actual coordinates of the points into the coordinate list. Switch to mode Points with free Coordinates and modify the coordinates of the alignment points. To do so, click the alignment point in the live video image with the right mouse button, choose Points with free Coordinates and modify the coordinates in the appearing dialog. By adding an offset to the coordinates you can e.g. move the origin of the coordinate system by a specific amount.

If you are working with PSV-3D and the geometry scan unit and if you want to use the 3D alignment in Points with free Coordinates mode but the position and/or coordinates are not known precisely, use the points with the free coordinates for the scanning head Top only. Add additional alignment points for the scanning heads Left and Right. You have to position the laser Top to these alignment points, too, because the scanning head Top is used to measure the distances to this points, but during alignment the points are only used for the scanning heads Left and Right. As a result you obtain a 3D alignment where the object system is defined with the same accuracy as the free coordinates you used for the scanning head Top. However, the accuracy of the relative positions of three scanning heads to each other is higher, which is important for the accuracy of the laser positioning and the coordinate transformation during the vibration measurement scan.

If you are using the geometry scan unit to acquire the 3D geometry of the object, first define the "raw" geometry using APS mode standard. Make sure that all points are well apart from edges of the object under investigation and are fully hit by the geometry laser. Then perform the geometry scan. After this switch to APS point mode and add the more delicate points near to the edges of the object under investigation. Note that you can use the hand set PSV-Z-051 or the PSV-A-PDA to position the laser beam directly at the object and teach in the points. This minimizes the effects of a non perfect standard alignment on the acquisition of the 3D geometry.

If you repeatedly work with the geometry scan unit to measure distances, e.g. while defining alignment points in 3D alignment or teaching in geometry points in APS point mode, switch to the geometry laser by selecting Scan > Geometry Laser. This saves time because now the software does not switch from and to the vibrometer laser any more for every distance measurement.

Use the hand set or the PDA and select Scan > Auto Align in the menu bar to define alignment points with the hand set or the PDA in 3D alignment. With the hand set or the PDA you are free to walk around, go to the object under investigation, position the laser beam there and define new alignment points. With the hand set or the PDA you can position the laser beam more precisely than by looking at the live video image.

Appendix A: Introduction to Complex Numbers

A.1 Representation of Complex Numbers

Complex numbers are underlined in this section.

A complex number consists of a real part and an imaginary part

$$\underline{Z} = \mathrm{Re} + i \cdot \mathrm{Im} \qquad \text{Equation A.1}$$

Re ... Real part of $\underline{Z}$
Im ... Imaginary part of $\underline{Z}$
i ... Imaginary unit, $i = \sqrt{-1}$.

As an alternative to the presentation with a real and an imaginary part, complex numbers can also be described with an absolute value and a phase (Euler's formula)

$$\underline{Z} = |\underline{Z}|e^{i\varphi} \qquad \text{Equation A.2}$$

$|\underline{Z}|$ ... Absolute value of $\underline{Z}$
φ ... Phase of $\underline{Z}$
e ... Euler's number (e = 2.718 ...).

The exponential function with an imaginary argument can be replaced by trigonometric functions

$$e^{i\varphi} = \cos\varphi + i\sin\varphi . \qquad \text{Equation A.3}$$

This results in

$$\underline{Z} = |\underline{Z}|\cos\varphi + i|\underline{Z}|\sin\varphi \qquad \text{Equation A.4}$$

$$\mathrm{Re} = |\underline{Z}|\cos\varphi \qquad \text{Equation A.5}$$

$$\mathrm{Im} = |\underline{Z}|\sin\varphi . \qquad \text{Equation A.6}$$

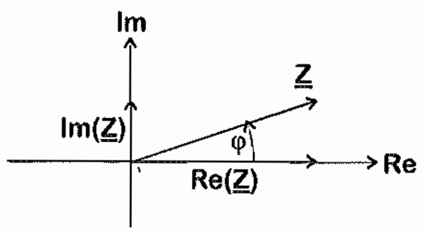


Figure A.1: Graphical presentation of a complex number

The complex plane is a coordinate system with real numbers in x direction and imaginary numbers in y direction.

A complex number $\underline{Z}$ is depicted as a pointer in the complex plane. Real part $Re(\underline{Z})$, imaginary part $Im(\underline{Z})$, absolute value $|\underline{Z}|$ and phase φ can be taken from the pointer diagram. The phase is 0 if the pointer is in x direction and 90° if the pointer is in y direction.

A.2 Addition and Subtraction of Complex Numbers

Addition of complex numbers:

$$\underline{Z}_1 + \underline{Z}_2 = Re_1 + Re_2 + i(Im_1 + Im_2) \qquad \text{Equation A.7}$$

Subtraction of complex numbers:

$$\underline{Z}_1 - \underline{Z}_2 = Re_1 - Re_2 + i(Im_1 - Im_2) \qquad \text{Equation A.8}$$

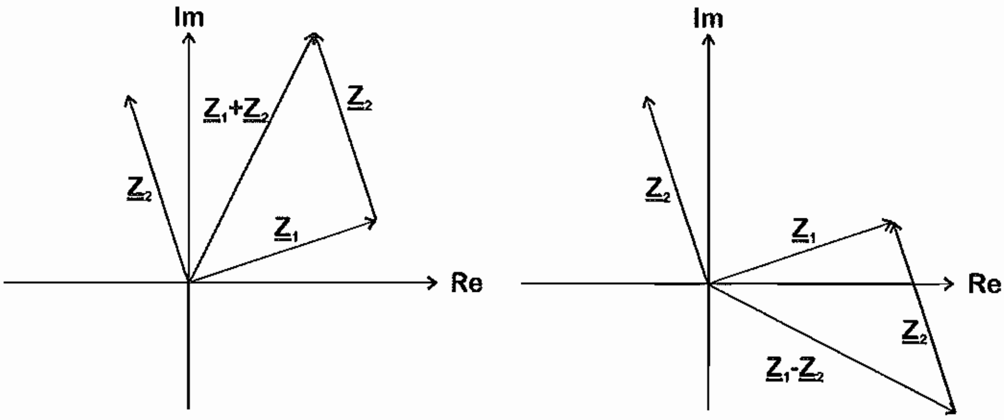


Figure A.2: Addition and subtraction of complex numbers

In the left pointer diagram two complex numbers are added by vector addition.

In the right pointer diagram the pointer Z_2 is subtracted from the pointer Z_1 by vector subtraction.

A.3 Multiplication and Division of Complex Numbers

Multiplication of complex numbers:

$$\underline{Z}_1 \cdot \underline{Z}_2 = Re_1 \cdot Re_2 - Im_1 \cdot Im_2 + i(Re_1 \cdot Im_2 + Re_2 \cdot Im_1) \qquad \text{Equation A.9}$$

The multiplication is much simpler if the complex numbers are described with an absolute value and phase

$$\underline{Z}_1 \cdot \underline{Z}_2 = |\underline{Z}_1| \cdot |\underline{Z}_2| \cdot e^{i(\varphi_1 + \varphi_2)}. \qquad \text{Equation A.10}$$

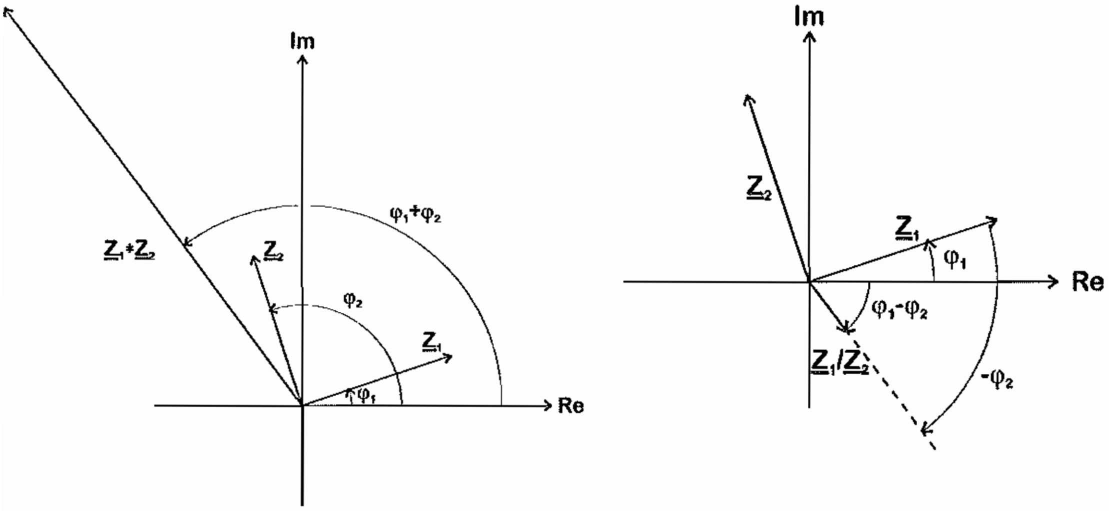


Figure A.3: Multiplication and division of complex numbers

Two complex numbers are multiplied by multiplying the absolute values and adding the phases

$$\frac{\underline{Z}_1}{\underline{Z}_2} = \frac{|\underline{Z}_1|}{|\underline{Z}_2|} \cdot e^{i(\varphi_1 - \varphi_2)}. \qquad \text{Equation A.11}$$

Two complex numbers are divided by dividing the absolute values and subtracting the phases.

A.4 The Complex Conjugate

he complex conjugate of Z is

$$\underline{Z}^* = \mathrm{Re} - i \cdot \mathrm{Im}. \qquad \text{Equation A.12}$$

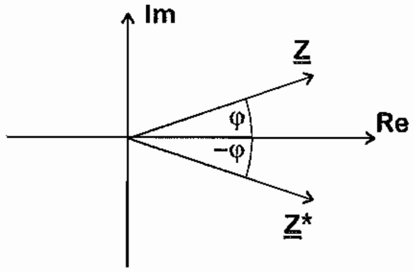


Figure A.4: Conjugated complex of Z

In the pointer diagram the complex conjugate develops through reflection on the real axis.

According to the multiplication rules the following applies

$$\underline{Z}^*\underline{Z} = |\underline{Z}| \cdot |\underline{Z}| \cdot e^{i(\varphi - \varphi)} = |\underline{Z}|^2. \qquad \text{Equation A.13}$$

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